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THE NORTH AMERICAN TROCHILISCIDS, PALEOZOIC CHAROPHYTA[1]

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ABSTRACT

An excellently preserved group of trochiliscids from the Devonian and Lower Mississippian rocks of North America is figured and described. This group is represented by two genera, *Sycidium* and *Trochiliscus*. Both genera are redefined and several new species described. This is the first recorded occurrence of either genus in the Mississippian and the first record of *Sycidium* in North America.

Because of excellent preservation of these trochiliscids through silicification it has been possible to describe several new structures. The presence of color bands in some specimens representing the genus *Trochiliscus* indicates the cellular structure of the shell. This evidence, combined with the identification of the oospore membrane and the hitherto unrecorded coronula cells definitely proves their charophyte affinities. The preservation of the oospore membrane in North American representatives of the genus *Sycidium* combined with the peculiar cellular structure of the shell illustrated by Karpinsky with the Devonian forms of Europe definitely proves the relationships of this group with the Charophyta.

Since the discovery, in 1849, of certain minute spherical bodies generally termed trochiliscids, there have been regular additions to our knowledge of their structure, geographic distribution, and geologic range. The relationships and the systematic position of the trochiliscids have been matters of considerable disagreement. Although these bodies have been generally considered most closely related to primitive plants they have been variously designated as lycopod spores, phyllopod eggs, fish eggs, Echinoidea, and foraminifera. Some present day investigators, as well as earlier workers, have maintained that they represent primitive charophytes, but authorities on living Charophyta have consistently excluded them from that group. It has been known since 1871 that the trochiliscids were represented in various Devonian formations of North America, but American workers have contributed very little to our knowledge concerning them.

In the latter part of 1930, through problems concerning sedimentation in the Sylamore (Kinderhookian) formation of Missouri, my attention was called to the presence of the spiral group of trochiliscids in great abundance in this formation near Williamsburg, Missouri. This in itself was a startling occurrence, inasmuch as it was the first record of these forms in the Mississippian anywhere in the world. Further investigation showed that not only were the spiral

[1] This paper was submitted to the Graduate Faculty of the University of Missouri in May, 1931, as partial fulfilment of the requirements for the degree of Doctor of Philosophy.

trochiliscids present in abundance but that another group, the pitted spheres, were also represented in great profusion. This is not only the first time the pitted spheres have been noted in North America, but is the first record of them outside of the Devonian anywhere in the world.

Acknowledgments.—Many facts concerning modern Charophyta that would be most useful in interpreting these ancient forms have been generally neglected in the extensive charophyte literature. Being unable to find precise statements of certain morphological facts, I have had to depend in no small measure on the advice given me by men who have made comprehensive studies of the living forms. Mr. James Groves, Isle of Wight, England, has been especially kind in giving from his vast store of information concerning the charophytes. To Dr. A. Karpinsky of Leningrad, I am indebted for information and advice transmitted by personal correspondence with his daughter, Madame Tolmatchoff Karpinsky. Dr. Julius Pia, Natural History Museum, Vienna, has been of great assistance in locating European bibliographies and references published since Karpinsky's monograph. Dr. R. S. Bassler, Dr. E. M. Kindle, Mr. R. F. D. Wickenden, Dr. C. O. Dunbar, Dr. A. K. Miller, Mr. Carmer, and Herberta L. Van Pelt, have made their collections of trochiliscids available to me for study and description. Throughout the preparation of the work Dr. E. B. Branson and Dr. M. G. Mehl have been most generous in advising on the many problems that have presented themselves.

For the series of original pictures of these remarkably well preserved specimens I am indebted to my wife, Mrs. Vaona Hedrick Peck, for retouching the photographs and preparing the drawings for the original text figures, and to Mr. Leon Waughtal, University of Missouri photographer. The retouching of the photographic base was done under my supervision with constant reference to the specimens and it has been our object to give as true a representation as possible of the form and structure of the specimens as they appear under the binocular microscope. No restorations or interpretations have been made.

HISTORICAL REVIEW

Almost a century ago (1849), G. Sandberger (38, 39)[2] called attention to a small organism from the Middle Devonian rocks of Eifel. He called this "polyp" *Sycidium* (Pl. 9, fig. 1) and gave the following generic diagnosis:[3]

Sycidium Feigen-Polyp. Char. Polyparium abbreviato-pyriforme vel sublogulare. altero apice magis producto perforatum. Costae longitudinales, ex apicis obtusioris centro parum impresso regulariter proficiscentes, canales satis excavatos intercludunt costulisque transversalibus junguntur.

The single species, *S. reticulatum*, was described as having twenty longitudinal costae with numerous rather sharply defined cross ridges. The length and width were given as 1.5 mm. and 1. mm. respectively.

A few years later (1856) Pander (26), in his geologic investigations in the region of Leningrad, found "minute problematic fossils" associated with fish remains in Devonian deposits. He described them as "small round ribbed bodies that we will call Trochiliscids" and considered them related to the lycopods. The following year Pander (27) again mentioned trochiliscids, describing them as "small round reticulated bodies" and again noting their occurrence with fish remains. In the light of later studies

[2] The numbers refer to references in the bibliography.

[3] Prof. Walter Miller of the University of Missouri has kindly translated the above description as follows: "Abbreviate pyriform or slightly globular polyparium, perforated at one apex which is somewhat lengthened. Longitudinal costae, extending in regular order from the slightly sunken center of the more blunt end, enclose quite deepened canals, and are joined by small transverse costae."

it may be assumed that Pander referred in the first instance to both the spirally and longitudinally ridged forms. In the second case he may have had before him representatives of both types, but evidently referred particularly to Sandberger's genus *Sycidium*. Pander did not attempt generic or specific descriptions, nor did he figure the organisms, but was evidently merely suggesting a group name to include both types.

Ehrenberg (10), in 1858, working with specimens from the same region in which Pander had gathered his material, redescribed these forms and referred them to the foraminiferal genus *Miliola*. He pointed out that Pander had been in error in assigning relationships with the lycopods, saying that they differed in structure and were from forty to eighty times larger than any known lycopod spores. He added that one could easily consider the oval and the spiral forms separate species. It is evident from Ehrenberg's description and comment that his investigation included the pitted forms described by G. Sandberger as *Sycidium* and the spiral forms which were later designated by various authors under the generic names *Calcisphaera*, *Saccammina*, *Moellerina*, and *Trochiliscus*.

Ehrenberg (11) in 1862 noted these problematic organisms from the Devonian of Russia and illustrated both the spiral and pitted spheres.

The next mention of the trochiliscids is by Quenstedt (33) in 1861. He pointed out the problematic nature of these forms, stating that they remind one of eggs of animals (phyllopods), but that they might be classified better among the single-chambered foraminifera, or with fossil lycopod spores.

Quenstedt (34) in 1867 gave an illustration of *Sycidium* and stated that these forms might be referred to the Charophyta or to the eggs of animals.

The microscope was first brought into use in the investigation of the trochiliscids by A. Lagorio (20) in 1876, who stated that his material was presented to him by Pander. He agreed with Ehrenberg in every detail of his investigation except to state that his specimens were filled with calcite that had gained entrance through the single opening.

Trautschold (44), in 1880, called attention to the exceptionally large number of trochiliscids in the Devonian of Sjass, where "they appeared in millions" and "filled entire slabs of sandstone." These forms were evidently representative of the genus *Sycidium* as they were described as having fifteen roll-like elevations between which were found rather constricted pits that also numbered fifteen. Trautschold spoke of the possibility of these forms being single-chambered Foraminifera or Echinoidea, but considered the shell too thick. He pointed out they were found only in association with fish remains and might possibly be the eggs of Devonian "Panzerfische," stating that these fish were so odd that the possibility should not be overlooked.

Later in the same year F. Sandberger (37) published a description of specimens from Sjass and named them *Sycidium melo*. He differentiated his *Sycidium melo* from *Sycidium reticulatum* G. Sandberger in that the new species had a more convex form, fifteen longitudinal ridges instead of twenty, and numerous and narrow cross-ridges. He agreed with Trautschold in referring them to Pander's "Trochilisken" and considered them as Foraminifera, belonging to the Lagenidae. No illustration was given.

Deecke (9), in 1883, gave a detailed description of the forms from Sjass, described by F. Sandberger as *Sycidium melo*, accompanied by illustrations. His description stated that the forms were 1 mm. in cross section and from 1 to 1.3 mm. in length, that they were lengthened and pointed at one end and flattened at the other, and that an opening existed at either end. He further stated that eighteen to twenty longitudinal ribs were present instead of fifteen as in F. Sandberger's description, and that through a crossing of the longitudinal

and lateral ribs definite fields or pits were created between these points of union, and these pits were perforated by simple openings running from the outside to the interior of the test. Deecke believed that *Sycidium melo* F. Sandberger might be only a variety of *Sycidium reticulatum* G. Sandberger, a view in which Karpinsky (16, p. 123), at a later date, concurred. Deecke reviewed the different systematic positions in which *Sycidium* had been placed and expressed an opinion that this genus should be classified with the Siphonales, and that it was closely related to *Ovulites* Lamarck. *Ovulites* is a problematic Tertiary form that is generally believed to represent separate divisions of a plant resembling the modern *Penicillus*.

Two years later, 1885, Quenstedt's (35) third edition of the "Handbuch der Petrefaktenkunde" appeared with the "Trochilisken" included in the description of *Chara*, but with the statement that they might be the eggs of animals. The accompanying illustration was of a spiral form and showed the spirals ascending from the right to the left as in the modern Charophyta. Forms of Devonian age with sinistral spirals would constitute an essentially unique record entirely out of keeping with well established data and Quenstedt's illustration probably should be considered a misrepresentation.

The first reference to trochiliscids in North American strata was made by Meek (21, 22) in 1871 and 1873, in his description of *Chara*-like forms from the Devonian Corniferous (Columbus) limestones at Sandusky, Ohio.

> In the same matrix with the above described shell [*Trochonema tricarinata* Meek] I have been surprised to notice numerous minute bodies that I can scarcely doubt are really the fruits of the fresh water genus *Chara*. At any rate, they seem to present all of the external characters of the same. These little bodies are globose, about 0.05 of an inch in diameter, and each ornamented by nine strongly defined and very regularly disposed spiral ridges, which start on one side around a minute pit, and pass with perfect regularity spirally, so as to converge to an exactly opposite point on the other side, making each about one spiral turn in passing from side to side. If really the seeds of this fresh water genus of plants, they must have been carried into the sea by streams, and deposited where we now find them, along with numerous marine shells.

Williamson (48) in 1880 described a number of problematic forms from the Carboniferous of Wales under the generic name of *Calcisphaera* and referred forms from the Kelly's Island, Ohio, Devonian to this genus under the name *Calcisphaera robusta*. As is indicated below it is evident that the specimens from Kelly's Island do not belong to the group for which the name *Calcisphaera* was proposed.

Dawson (7), 1883, described forms from the same horizon and locality as *Calcisphaera robusta* Williamson under the name *Saccammina*? (*Calcisphaera*) *eriana*, considering them allied to *Saccammina globosa*. He noted the "resemblance to the spore-cases of *Chara*," but stated that the walls were granular and the structure entirely different from that of any vegetable organism.

The trochiliscids were again called to attention by Ulrich (45) in 1886, in his description of *Moellerina greenei* from the Falls of the Ohio. Due to a peculiar type of preservation, Ulrich's specimens were two-chambered in appearance and were described as Foraminifera. Accompanying illustrations show the spiral ridges ascending to the left, a feature entirely out of keeping with the abundant record of otherwise similar fossils from Devonian and Mississippian rocks, including specimens from the same horizon and locality as Ulrich's types. Unfortunately, the type material seems to have been lost so there is no way of verifying the opinion that the figures have been reversed in reproduction.

In 1889, Knowlton (19), evidently unaware of Ulrich's paper, described these

minute spiral bodies from the Falls of the Ohio, under the name of *Calcisphaera lemoni*. Knowlton, recognizing the problematic character of the forms, submitted them to such charophyte authorities as T. F. Allen of New York, A. Nordstedt of Sweden, and J. S. Newberry, in the belief that they should be accepted as relatives of the modern *Chara*. Allen expressed the opinion that (19, p. 205): "the little seeds you sent me are Foraminifera and not *Chara*." Specimens were submitted to H. B. Brady, of London, a well known worker on Foraminifera who reported (19, p. 205): "I do not in the least believe it to be foraminiferal." Knowlton also sent specimens to W. F. Farlow, of Cambridge, to determine their possible relationships with algae. Farlow's detailed report concluded (19, p. 206). "In short the fossil is very much less like any algae than like *Chara* spores, and they have already been excluded [from *Chara*] by competent experts." Finally, Knowlton described the forms as problematic organisms, with the suggestion that (19, p. 204) "there is, however, no vital objection to the supposition that this might have been an archaic or original type from which the more modern forms [of *Chara*] have been developed."

By far the most complete and important work on these problematic fossils appeared in a monograph by A. Karpinsky (16) in 1906. He advanced evidence to show that these forms were distinct Paleozoic branches of the Charophyta, and proposed two subdivisions, the "Sycididae" to include the longitudinally ridged forms, and the "Trochiliscidae" to include the spirally ridged forms. Each family contained one genus. A few new species and varieties were defined.

The spiral bodies are next mentioned under the name *Chara devonica* by Wieland (47), in 1914, from the Snyder Creek shale on Snyder Creek, Calloway County, Missouri. He compared these forms briefly with *Calcisphaera lemoni* Knowlton but did not figure them or describe them in detail.

Thomas (43) in 1921, mentioned the finding of abundant *Calcisphaera robusta* Williamson in the Devonian Lime Creek shale of Iowa.

Bell (1) in 1922, in describing a new genus of Charophyta from the Carboniferous of Canada, briefly reviewed the literature on North American Devonian forms (evidently Karpinsky's work was unknown to him) and came to the conclusion that the spiral sculpture was confined to ornamentation of the outer wall and involved no cellular structure. He was followed in this conclusion by Groves and Bullock-Webster (14), in their summary of the geologic history of the Charophyta.

Pia (28, 29), in 1920 and 1926, briefly reviewed Karpinsky's monograph and concurred in his conclusions to the extent of including both the "Trochiliscidae" and the "Sycididae" as probable Charophyta. The same author, however, (30) again reviewed the evidence, and while he accepted the representatives of *Trochiliscus* as probable Charophyta, he stated that *Sycidium* might better be classified with the Dasycladaceae or the Codiaceae. In a more recent work (31) Pia stated that, in his opinion, *Trochiliscus* should be classified with the Charophyta, but he failed to mention *Sycidium* in connection with the Charophyta, Dasycladaceae, or Codiaceae.

A report of the occurrence of representatives of the genus *Sycidium* in otherwise nonfossiliferous beds of the Belgian Congo has led to several important papers in the past few years by Choubert (4, 5) and Hacquaert (50, 51).

SOME CHARACTERISTICS OF LIVING CHAROPHYTA

The Charophyta constitute a small group of fresh and brackish water plants of somewhat doubtful affinities, ranked by some authorities as a class of the Thallophyta and by others as a separate phylum. They occur most abundantly in quiet bod-

ies of clear water such as ponds, ditches, or gravel pits, and are widely distributed throughout the world. Occasionally they are found in rivers and lakes and a few have been noted in the Baltic Sea, a body of marine water with unusually low salinity. However, they are considered typical fresh water plants and a marine occurrence of either living or fossil forms demands an explanation. Because they live completely covered by water they are inconspicuous, and being of no economic value the group has attracted very little attention. They are not well known except among botanists, but are of interest to geologists in that some species secrete calcium carbonate and are large contributors to some of the fresh water limestones.

The Charophyta are small somewhat bushy plants ordinarily ranging from about 4 inches to 2 feet in height. The stems are slender and branched. According to Groves and Bullock-Webster (13, p. 16) the outstanding characteristics of the group are the male and female reproductive organs, termed the antheridia and oogonia respectively, and the whorled growth of the lateral branches on which they are borne.

The antheridia and oogonia are very complex and highly organized bodies, entirely unlike those of any other plant, and it is because of them that the systematic position of the Charophyta is uncertain. These bodies develop at the nodes of the branchlets or at the union of the branchlets and stalk (Pl. 9, fig. 14).

The antheridia are subspherical in shape, ranging from 0.15 mm. to 1.2 mm. in diameter. The outer wall is made up of eight convex plates essentially triangular in outline (Pl. 9, fig. 7). These plates are grooved on the outside and the edges are irregularly crenulate. The antheridia do not calcify in modern charophytes and have not been recognized in the fossil state.

The original cell that is to form the female body, the oogonium, is first divided by a horizontal septum into a node-cell and an oosphere (Pl. 9, figs. 9*a–f*). At a later stage five small cells bud off from the outer surface of the nodal cell, elongate upwards, and envelop the oosphere. Each of these enveloping cells is then divided near mid-length by a horizontal septum producing ten small cells in two tiers of five. The lower group of cells continues to elongate and assumes a spiral form, twisted always from the right to the left. The upper cells remain small, and form a crown or coronula. The Charophyta are divided into two groups on the basis of the development of the coronula. The Chareae have a coronula of five cells, as described above, but in the Nitelleae these upper cells are again divided horizontally, and form a coronula of ten cells arranged in two tiers of five. The oosphere, around which the enveloping cells are wound, continues to enlarge with the growth of the enveloping cells until maturity is attained. At this stage the oogonia range from about 0.3 mm. to 1 mm. in length. In those species in which the coronula is deciduous the antherozoids gain entrance to the oosphere

through the summit opening formed by the loss of the coronula. If the coronula is persistent the upper ends of the enveloping cells are narrowed and leave small triangular openings through which the antherozoids enter. Charophyta are either dioecious or monoecious, and according to Groves and Bullock-Webster (13, p. 64), parthenogenesis has been observed.

After fertilization the oosphere becomes an oospore and develops a hardened outer covering of suberin and silicic acid[4] called the oospore membranes. These membranes, four in number, are described in detail by Groves and Bullock-Webster (13, p. 56).

Charophyte oogonia may be preserved as fossils by virtue of their ability to secrete extremely fine-grained calcium carbonate. This deposition starts on the concave inner walls of the enveloping cells adjoining the oospore and may almost completely replace the cell contents (Pl. 9, figs. 12 *a–c*). At maturity the lateral walls of the cells break down and the calcified portions of adjacent cells coalesce to form a "lime-shell" around the oospore. In the different stages of calcification the exterior of the lime-shell varies greatly in appearance (Pl. 9, figs. 12 *a–c*). If only a thin deposit is secreted the oogonia will possess very sharp spiral ridges with wide deep concavities, the ridges consisting of the sutures along the lateral union of the cells and the concavities representing the cells. The deposition may continue until, upon complete calcification, there is only a thin membrane of protoplasm remaining along the outer walls of the cell. With this development the cells are represented by broad spiral ridges instead of concavities and the sutures between the cells by narrow furrows. Any stage between the "concave cells" and "convex cells" may occur in the same species, and in rare cases, in the same individual.

Braun (3) and Migula (23) stated that the calcium carbonate was deposited in layers and that the layers were separated by thin protoplasmic membranes. However, these membranes have been noted in only a few instances in the modern forms and Migula (23, p. 49) observed that they could be more easily detected in *Chara hispida* than in any other species.

The degree of calcification seems to be dependent on a variety of factors. Karpinsky (16, p. 131) stated that apparently variations in the calcium content of the water had no influence on this process, but that in certain recorded instances variations in the light and sodium chloride content of the water had served as a check on the calcium deposition. He also stated (p. 130) that in rare cases the calcified portions and the oospore membranes were preserved as fossils by silicification, and cited *Lagynophora foliosa* Stache from the Eocene of Europe as an example.

Sinistrally spiraled charophyte oogonia are first abundant in the Tertiary. They occur sparingly in the Cretaceous of both Europe and

[4] Discovery of this chemical composition is attributed to Nordstedt by Groves and Bullock-Webster, British Charophyta, vol. 1, p. 54, 1920.

North America. In the Jurassic a number of forms has been discovered, in places in association with marine fossils. This marine occurrence is accounted for by Groves and Bullock-Webster (14, p. 78) as probable fresh water charophyte oogonia that were washed out to sea. The oldest undoubted charophyte oogonia so far recorded were described by Bell (1) as *Palaeochara acadica* from the Lower "Coal Measures" of Nova Scotia. Vegetable remains that resemble charophyte plants have been described by Potonie (32) from the Silurian on Kellerwald and by Kidston and Lang (18) from the Rhynie chert bed of the Old Red Sandstone of England. These remains were not associated with reproductive bodies and cannot be referred definitely to the Charophyta.

In all recent and presumably in all post-Mississippian charophyte oogonia the enveloping cells ascend from the right to the left. Several illustrations have been published showthe cells twisting in the opposite direction, but according to Groves (personal correspondence), these are probably all misrepresentations.

The number of spiral enveloping cells in post-Pennsylvanian oogonia is almost invariably five. However, Karpinsky (16, p. 136) cited several references in which authors noted from four to six enveloping cells or coronula cells. *Palaeochara acadica* Bell from the Lower "Coal Measures" of Nova Scotia is characterized by having six spirals. In a recent number of the American Journal of Science, I described two species of five spiralled charophyte oogonia from the Cherokee (Lower Pennsylvanian) formation of Missouri.

In the living Charophyta neither the coronula nor the stalk cells calcify. Although the coronula has been noted by several authors in describing fossil charophyte oogonia, there is some question as to the correctness of these observations. Mr. James Groves of England has kindly given me his opinion on this question as follows:

> Replying to your query about the coronula, so far as I can ascertain this organ has never been found in a fossil state. In the living plants neither the coronula nor the stalk-cell take up lime in the way that the spiral-cells do, and it is to this fact that their absence in the fossil "fruits" is attributed. The tips of the spiral-cells of some living species and of many of the fossils are much swollen, and in the fossils this is accompanied by a certain shrinkage below the tips giving an impression of their being separate cells, and in consequence they have been taken for the coronula.

This lack of coronula cells in fossil forms has made their classification difficult. As has been pointed out, Charophyta are divided into two groups on the basis of the coronula cells, the Chareae and the Nitelleae.

In addition to the fossil charophyte oogonia that range from Pennsylvania to Recent in age, another more ancient group of small "charophyte-like" bodies, the trochiliscids, has been referred to the Charophyta by some authors. The trochiliscids are a group with problematic affinities that occur abundantly in the Devonian of Russia and Germany, and in the Devonian and Lower Mississippian of North America. They are divided in-

to two distinct groups. One of these, the Trochiliscaceae, consists of small spiral bodies, remarkably like the recent Charophyta and agreeing with them in many details. They differ in that they occur in marine deposits, the spiral cells of the oogonia twist to the right instead of to the left, and the number of the enveloping cells is greater than five. The members of the other group, the *Sycidiaceae*, are small bodies longitudinally and laterally ridged, with little external resemblance to the oogonia of recent Charophyta. However, they are closely associated in the strata with representatives of the Trochiliscaceae and resemble them in their internal structures.

MORPHOLOGY

The Trochiliscaceae.—The morphology of the Trochiliscaceae is essentially the same as that described above for the oogonia of the living charophytes. Evidently the original cell that was to form the oogonium first divided horizontally into two cells, the node cell and the oosphere. Later from seven to ten small cells budded from the outer surface of the node cell and elongated upwards to clasp the minute oosphere. These cells divided transversely and the resulting lower series, the *enveloping cells*, elongated and twisted dextrally with the enlargement of the oosphere to form the oogonium wall. The upper series, the *coronula cells*, remained small and formed an erect parapet-like ring around the summit opening.

In the living charophytes fertilization of the oosphere is accomplished by the antherozoids gaining entrance through the summit opening when the coronula is deciduous, or between the apical ends of the enveloping cells when the coronula is persistent. Apparently all the Trochiliscaceae possessed a summit opening for the entrance of the antherozoids, and the coronula cells formed around the opening instead of filling it as in the living charophytes. Upon fertilization the oosphere became an oospore and developed a hardened outer covering corresponding to the oospore membrane of the living charophytes. The oospore membrane of the Trochiliscaceae was evidently much the same in composition as that of the living forms. It is normally preserved as cryptocrystalline silica in specimens that otherwise are crystalline quartz. The membrane is usually contracted, sometimes folded, but occasionally in contact with the inner side of the oogonium wall.

Deposition of calcium carbonate was first started in the enveloping cells on the concave inner walls adjoining the oospore (see Pl. 9, figs. 12 *a–c*), and in some species, in the interior of the coronula cells. At maturity the lateral walls of the enveloping cells broke down and the mineral content of adjoining cells coalesced to form the unified lime-shell. In many cases, calcification ceased after this thin initial deposit and the enveloping cells of these oogonia are represented by wide furrows, separated by sharp intercellular ridges that mark the boundaries of adjacent cells (Pl. 11, figs. 14, 17). If deposition continued in the en-

veloping cells the shell thickened and the intercellular ridges widened and flattened as the cellular furrows narrowed and became slightly more shallow. These later layers are separated from those of the adjoining cells by slight grooves on the intercellular flat-topped ridges (Pl. 11, fig. 6). Deposition often continued until the enveloping cells were almost completely calcified. The enveloping cells were then represented on the outer surface by broad rounded ridges, separated by narrow furrows, the furrows representing the original intercellular ridges. In the living charophytes the deposition is greater near the base, and this portion of the cells is the first to become completely calcified. Exactly the opposite is the case in the Trochiliscaceae, in which the upper parts of the cells were the first to become completely calcified.

The coronula cells of the living charophytes do not secrete calcium carbonate and are probably never preserved on post-Mississippian fossil oogonia. They have been recorded by several authors, but according to Groves these observations were probably incorrect. In some forms of the Trochiliscaceae the coronula cells did calcify in part, and various degrees of calcification can be noted as in the enveloping cells. On these forms the coronula cells are normally retained, but occasionally are absent and their former presence indicated by shallow pits around the summit orifice. On several specimens in our collections a few coronula cells are preserved and pits mark the former location of the others. On some of the Trochiliscaceae the coronula cells, if present, did not calcify. On such specimens the apical ends of the calcified portion of the enveloping cells are united in an elevated ring around the summit opening, with no pits marking the former location of coronula cells. There is little possibility for mistaking these "non-coronulate" forms for "coronulate" specimens that have lost the coronula cells.

The factors controlling the degree of calcification attained by the enveloping cells of the oogonia of living charophytes have not been satisfactorily determined. In certain recorded cases, according to Karpinsky, variations in the light and sodium chloride content of the water have been effective, and it seems quite plausible to suppose that the calcium content of the water would have a marked influence. Normally all the Trochiliscaceae from one locality have approximately the same degree of calcification, but in the "Williamsburg locality" of the Sylamore a great variety of calcification stages are noted, a condition for which I have no plausible explanation.

The Trochiliscaceae have been variously classified and have never been generally accepted as ancient relatives of the Charophyta. However, many of the forms described herein show definitely the cellular nature of the walls and retain the coronula cells and oospore membrane. These are all structural features corresponding with those of the living Charophyta, and it seems impossible longer to deny the Trochiliscaceae a

place with that group. The Trochiliscaceae differ from the living Charophyta in only three characters: the dextral twist of enveloping cells, the larger number of enveloping cells, and their marine occurrence. It seems entirely feasible to assume that they were a separate branch of the charophyte group that acquired the ability to secrete calcium carbonate during Early Devonian times and were adapted to a marine habitat. Our present record indicates that this group became extinct before the end of the Paleozoic. The modern type of Charophyta, with sinistrally spiraled oogonia, and at the present time almost entirely restricted to a fresh water habitat, has been found as far back as the Pennsylvanian. It may be assumed that they existed at an earlier time, but first acquired the ability to secrete calcium carbonate during the Pennsylvanian period.

The Sycidiaceae.—Sycidiaceae have been collected from only one formation in North America, the Sylamore (Kinderhookian), and have been found in abundance at only one locality. The original calcite shells of these forms have been completely replaced by crystalline quartz and all trace of structure in the shell walls has been lost. However, their gross structures are the same as the European representatives of *Sycidium* and the identity of these North American specimens cannot be questioned. The remarkable preservation of some of the European specimens described by Karpinsky (16) shows many details of the cellular structure of the walls. The American forms add a knowledge of the oospore, a feature not recorded in European representatives. The combined evidence in the two groups now makes it possible to outline the morphology of the Sycidiaceae with the same degree of assurance as is possible with the Trochiliscaceae.

Representatives of the Sycidiaceae have been found in great abundance in the Devonian of Russia and Germany. In these the shell is preserved as calcite, and in many cases evidence of the original structure is preserved. Karpinsky (16) has described these forms in great detail and it is from his work that the following analysis is largely drawn.

The Sycidiaceae are small thick-shelled oogonia with retiform surface sculpture, the sculpture originating through a crossing of meridional and horizontal ridges leaving the intervening areas depressed; or, on filling out of the depressed areas the meridional and horizontal ridges become furrows. The lamellar arrangement of dark-colored bands (included organic matter) in each of the pits—tubercles if filled out—indicates that each unit was a separate cell and was calcified independent of adjoining units. This is clearly shown in several sections illustrated by Karpinsky, one of which is reproduced herewith (Pl. 13, fig. 13). The calcifying process in the Sycidiaceae appears to be analogous to that of the Trochiliscaceae; if complete calcification of the cells was attained the cells are represented by nodes, if not, by shallow pits. In the first case the oogonium is a nodose sphere, in the second case a pitted sphere.

It will be recalled that in the developmental stage of the charophyte oogonium the original cell divides into a node-cell and an oosphere. Later five small cells separate off the outer surface of the node-cell, elongate upwards enveloping the oosphere, and in the Chareae, divide horizontally to form an envelop of ten cells arranged in two tiers of five, the upper tier remaining small and forming the coronula. In the Nitelleae a second horizontal division takes place and the envelop consists of fifteen cells arranged in three tiers of five, the upper two tiers remaining small and forming the coronula. These horizontal divisions take place before the enveloping cells start their sinistral twist (see Pl. 9, figs. 9 *d–e*). Karpinsky believes that the formation of the shell of the Sycidiaceae was in all essentials the same as in the Chareae and Nitelleae. He assumes that approximately eighteen small cells were separated from the outer surface of the node-cell instead of five as in the modern type of Charophyta or seven to ten in the Trochiliscaceae. The eighteen small cells elongated upwards, enveloped the oosphere, and were divided by twelve to eighteen horizontal sutures (see Pl. 9, figs. 10, 11), instead of one as in the modern Chareae or two as in the Nitelleae. This cell division formed an oosphere envelop consisting of a large number of individual cells. Karpinsky's conception of a restored Sycidiaceae oogonium is reproduced in Plate 9, figures 8 *a*, *b*. That each of these small cells was independent of adjoining units is indicated by the slightly concave laminae which illustrate the successive layers of deposition within the cells. In the Sycidiaceae, as in the Trochiliscaceae, the degree of calcification varied. The incompletely calcified cells are represented by pits bounded by horizontal and longitudinal ridges, the intercellular sutures. The completely calcified cells are represented by nodes, the former intercellular ridges having been converted into narrow furrows. Further evidence of the independence of each of these units is shown in their arrangement, some being in lateral alignment and others alternating in position in adjoining rows. Both the alternating and the lateral alignment arrangement may occur on the same individual and almost always do on the North American *Sycidium foveatum* Peck. It was pointed out by Karpinsky that, if the enveloping cells did not twist, a greater number was necessary to completely cover and protect the oosphere. Additional meridionial units were probably acquired by vertical division of the bud cells. Evidence of this is indicated in the base of *Sycidium foveatum* (Pl. 13, fig. 24). Although no specimens with perfectly preserved basal areas were found the figured specimen indicates that an original number of nine cells budded from the outer surface of the node-cell, which occupied the perforation described as the basal opening. These nine cells divided vertically to form a total of eighteen meridional units around the oosphere. A greater number of short vertical units made it possible to completely encase the

oosphere without twisting spirally and for this reason, perhaps, the enveloping cells of the Sycidiaceae remained meridional in position.

Karpinsky noted that eighteen meridional units was evidently the normal number for each species but that variations within narrow limits did occur. A comparatively rare American species, *Sycidium clathratum* Peck, consistently possesses only sixteen meridional units and is otherwise easily differentiated from *Sycidium foveatum*, from the same horizon and locality, by the characteristic size and shape. Although there is no evidence indicated on the poorly preserved basal areas of representatives of *Sycidium clathratum*, it is probable that the sixteen meridional units were developed from eight bud cells which possibly were not calcified. Specimens with odd numbers of units (15, 17, 19) are occasionally found. Each of these is to be classed with the even numbered form of the next greater magnitude, inasmuch as they always agree in other details with the even numbered forms and occasionally show evidence of the suppression of one column of cells.

Sections of the silicified American specimens ordinarily show a comparatively thin-walled inner sac of cryptocrystalline silica suspended from the summit opening (Pl. 13, fig. 16), as in the Trochliscaceae. In a few forms this sac is represented by a thin layer of cryptocrystalline silica adjoining the inner side of the oogonium wall, but it is usually greatly contracted and may be folded. This structure represents the hardened outer covering of the fertilized oospore, the oospore membrane.

In summary, the oogonia of the Sycidiaceae differ from those of the Trochiliscaceae and the Chareae in: (1) the longitudinal units ascending vertically—as in the developmental stages of the Chareae oogonia—and remaining straight, (2) in having a greater number of longitudinal units —a necessary modification for the protection of the oospore as short vertical units would not cover as much space as the same number of long twisted units, and (3) in having the longitudinal units divided transversely into a large number of small units, instead of two as in the Chareae or three in the Nitelleae.

The Sycidiaceae have been variously classified as polyps, fish eggs, phyllopod eggs, Foraminifera, Echinoidea, and Siphonales. Karpinsky reviewed all of these possibilities and advanced conclusive evidence to show that each was untenable. In spite of his most excellent and well drawn conclusions, later authors have shown a marked tendency to consider the Sycidiaceae as representative of the Siphonales.

This tendency is probably caused by Deecke's (9) explanation and illustrations of *Sycidium melo* F. Sandberger. Deecke arranged the Sycidiaceae with *Ovulites* Lamarck, a Tertiary fossil that is generally considered to be a separate unit of the branch of a plant resembling the modern *Penicillus*. Sycidiaceae that are abraded or that show effects of solution often give an indication of pores where the shell has been worn

through and the opening filled with foreign material. Deecke evidently possessed specimens so preserved and from them constructed an ideal cross-section showing a pore through the shell for each pit. Such openings do not occur on well-preserved specimens and no indication of them can be observed in sections, as pointed out by Karpinsky and substantiated by my own observations. Karpinsky's illustrations show conclusively that such pore space cannot exist. Karpinsky compares the two forms in great detail and concludes that there can be no relationship between a plant like *Penicillis* and *Sycidium*. Although group summaries have referred them to the Siphonales since Karpinsky's work, in no case has this grouping been done as a result of a careful study of well-preserved specimens.

Choubert (5, p. 67), in his study of the Sycidiaceae from the Devonian of the Belgian Congo, also considered the development of pores in the shell and concluded that they were formed by solution of acid waters.

Hacquaert (50), has recently made a detailed study of thin sections of representatives of the genus *Sycidium* and concludes (p. 10) that the solution of the test is too irregular to permit mistaking the cavities thus formed for pores.

With the cellular structure of the Sycidiaceae as made known by Karpinsky, and the discovery of the oospore membrane as outlined above, there is little reason to question the assignment of this group to a place among the charophytes.

MATERIALS AVAILABLE AND METHODS OF STUDY

My attention was first directed to the trochiliscids through the opportunity of studying a remarkably abundant and well-preserved group of both spirally and longitudinally ridged forms from the Sylamore (Basal Mississippian) of central Missouri. The outcrop in which these specimens were discovered was very restricted both horizontally and vertically, and the collecting was extended to other Sylamore outcrops and to other horizons in order to determine the geographic and stratigraphic distribution. The Sycidiaceae were found to be restricted to the Sylamore and of infrequent occurrence at other localities at which this formation outcropped. The Trochiliscaceae were found to be sparsely distributed in other Sylamore outcrops and were collected in abundance from certain Snyder Creek (Upper Devonian) localities. Other specimens were made available for comparison and study from the Devonian of Indiana and Ohio, the Devonian Bell shale of Michigan, the Devonian Hackberry stage of Iowa, and the Devonian of Saskatchewan, Canada (see fig. 1).

Because of the gregarious habits of these ancient charophytes and the limited set of conditions under which they could grow they are not widely distributed in formations in which they occur, but are usually found in large quantities in restricted localities, as is the case with the recent charophytes. In the Sylamore locality in which these bodies were first discovered several hundred specimens were obtained from approximately a pint of washed material, and in some Snyder Creek localities they occur even more abundantly. Williamson (48) stated that the trochiliscids make up the greater part of the limestone in which they occur at Kelly's Island, Ohio, and Trautschold (44) observed that they "appeared in millions" and "filled entire slabs of sandstone" in certain parts of the U.S.S.R. However, according to my experience, in nearby

outcrops of the same formation from which they have been collected in quantities, large samples may yield few or no specimens and those that do occur are frequently worn and bear evidence of having been shifted by current action.

The original shell material of the trochiliscids was evidently calcium carbonate and built up in the same way that the protoplasmic contents and then a recrystallization of the material comprising the lime-shell. According to Karpinsky (16, p. 133, fig. 18) a single crystal of calcite may include both a portion of the inner cavity and a portion of the outer wall. Ordinarily the crystals on the interior are much larger than those making up the lime-shell. In rare cases

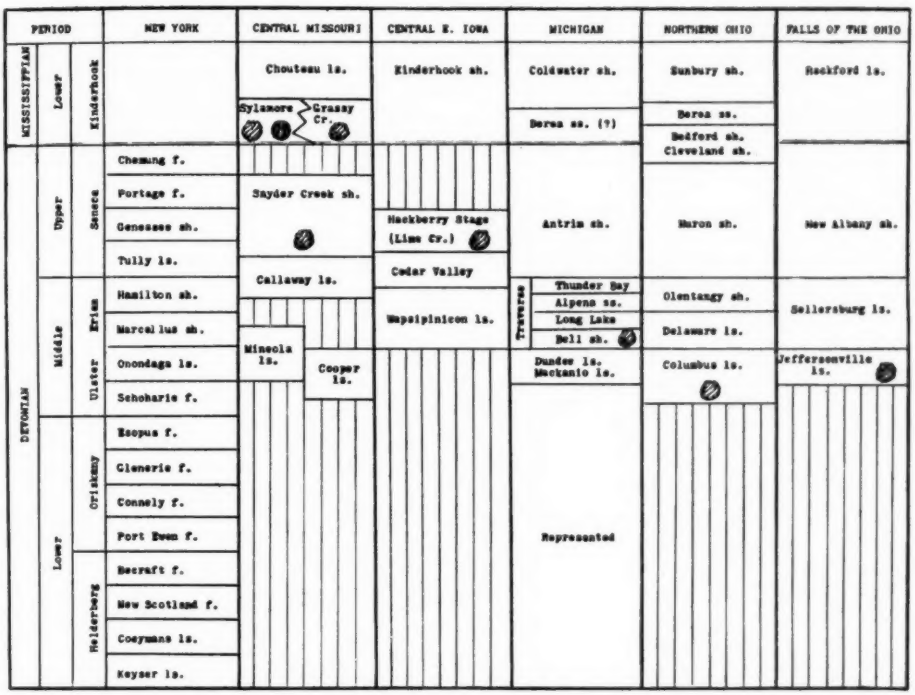


FIG. 1.—Correlation chart showing distribution of the trochiliscids. Compiled from United States Geological Survey Correlation Charts and Branson, E. B., Devonian of Missouri: *Missouri Bur. Geology and Mines*, 2d ser., vol. 17, 1923.

it is in the living charophytes. In every recorded occurrence of these forms, with the exception of the silicified specimens from the Sylamore of Missouri and Devonian at the Falls of the Ohio and Sandusky, Ohio, they have been preserved as crystalline calcium carbonate, the crystals often large in relation to the size of the specimen. Preservation was evidently accomplished by filling the inner cavity upon decomposition of sufficient organic material is contained in the outer wall to show definitely the lamellar deposition of calcium carbonate in the enveloping cells (Pl. 12, fig. 10). As a rule, all organic material is lost in the calcified trochiliscids and this is undoubtedly the reason some authors have found that the spirals were confined to ornamentation of the outer wall.

The original shells of the Sylamore trochiliscids have been completely re-

placed by crystalline quartz or, more rarely, white cryptocrystalline silica. Upon the decomposition of the oospore, silica-bearing solutions filled the hollow interiors of the oogonia and formed quartz crystals of fairly large size. In the Trochiliscaceae this was followed by a replacement of the lime-shell with quartz crystals of smaller size in which the original coloring matter shows clearly the cellular nature of the shell and the lamellar deposition of the original mineral matter (Pl. 11, figs. 17, 20). In the outer walls of the Sycidiaceae all trace of structure has been lost. The oospore membranes are represented in a large number of specimens of both Sycidiaceae and Trochiliscaceae by an inner sphere of white cryptocrystalline silica. In the majority of Sylamore localities the trochiliscids are absent or represented only by internal molds, the oogonium wall having been lost. These molds appear as minute globular bodies with indentations at the ends corresponding to the polar openings of the oogonia. In sections many of the molds reveal the oospore membrane.

Siliceous fossils are the rule rather than the exception in the Sylamore. The formation is not highly fossiliferous but the majority of fossils contained in it are silicified. The trochiliscids from the Sylamore at Williamsburg occur with silicified ostracodes and a few silicified brachiopods.

The Devonian Trochiliscaceae from the Onondaga of Indiana and Ohio occur as silicified fossils in chert. Only a few specimens from this locality were available for study, but their preservation was much the same as the Sylamore forms with the exception that all trace of structure in the outer walls had been lost. Only the silicified lime-shell and the oospore membrane were preserved. The oospore membrane had contracted slightly and pulled away from the outer wall thus giving the two-chambered appearance that probably led Ulrich to describe his specimens as Foraminifera.

Judging from the material described in previous works, trochiliscids have been collected almost altogether from limestones and sandstones, although Karpinsky (16) noted their occurrence in shales. It has been my experience that they are found abundantly in shales and sandy shales. In North America the trochiliscids have been collected from cherty limestones on Kelly's Island and at Sandusky, Ohio, and at the Falls of the Ohio, from shales in Michigan, Iowa, and Missouri, and from sandy shales in Missouri. These shale occurrences, with one exception, are of Devonian age and the specimens collected from them are ordinarily distorted, a condition undoubtedly caused by the compaction of the shales. The Sylamore specimens have been silicified and are preserved in sandy shales. Specimens from this formation with convex cells are almost always perfectly preserved and the thin-shelled forms are but slightly distorted.

The shale and sandy shale occurrences of the trochiliscids make their preparation for study comparatively simple. Samples are collected from the outcropping formations, preferably partially weathered material, and brought into the laboratory for boiling and washing. Slow boiling breaks down the lithifaction and brings the fine clays into suspension, and frequent washings reduce the sample in a comparatively short time to a clean residue. The residue is dried by placing in an oven or directly over a slow heat and stirring frequently to prevent sticking. The sample is then sized by screening. Specimens are segregated by brushing through the material under binoculars and picking out the trochiliscids with a dampened brush. Almost invariably it is necessary to further clean the specimens as there are small crystals of calcite or quartz matrix cemented to the shell and lodged in the depressions. The specimens are mounted by cementing in recessed microslides and cleaned with a very sharp needle under binoculars. The matrix is easily separated from the shell

wall and this method is much more satisfactory and less likely to damage the specimens than attempts to clean with acid. However, on some of the silicified specimens a slight etching with a weak solution of hydrofluoric acid is necessary to bring out the sutures between the coronula and enveloping cells.

CLASSIFICATION

Aside from efforts to prove or disprove the relationships of the trochiliscids with the living Charophyta, but little has been accomplished toward placing them in a logical classificatory system. In general, the work on the trochiliscids has consisted of definitions of genera based, for the most part, on new occurrences and slight differences in external appearance. There has been essentially no effort made to compare the new forms with previously described genera. Until the present there has been slight need for specific differentiations inasmuch as each species proposed has also been made the type of a new genus. The single exception to this procedure is Karpinsky's monograph in which he clearly differentiated the genera *Trochiliscus* and *Sycidium* and described several species representing each genus. Karpinsky was dealing solely with fossils and made no endeavor to place them in a classificatory scheme that would include living forms, other than to state that he believed the trochiliscids to be fossil charophytes. In addition to the genera and species defined in his monograph there were proposed two groups of greater than generic rank, the "Trochiliscidae" and the "Sycididae" (16, p. 157).

Apparently the only classification that has been suggested to include both living and fossil charophytes was made by Pia in Hirmer's "Handbuch der Paläobotanik." The major features of his grouping, omitting remains that do not include the spores, are as follows:

Class Charophyta

A. Unquestioned Charophyta
  1. Characeae
     Oogonium wall composed of five enveloping cells ascending with a sinistral twist.
     a. Subfamily Nitelleae
     b. Subfamily Chareae
     c. Subfamily Lagynophoreae
  2. Palaeocharaceae
     Oogonium wall composed of six enveloping cells ascending with a sinistral twist.
  3. Clavatoraceae
     Oogonium inclosed in an outer utricle or nut.

B. Doubtful Charophyta remains
   Genus *Trochiliscus*
   Genus *Sycidium*

Although the above outline does not offer a solution to the problem of classifying the trochiliscids it is of interest to the taxonomist because of the great emphasis placed on the number of enveloping cells in the "Unquestioned Charophyta." Group one, the Characeae, includes all of the forms in which the oogonium wall is composed of five sinistrally spiraled cells. Group two, the Palaeocharaceae, of equal rank with the Characeae, was proposed for a single genus and species from the "Carboniferous" of Nova Scotia. The outstanding character of the Palaeocharaceae is that the oogonium wall is composed of six sinistral spiral units. The Clavatoraceae, although represented by only one genus and possibly two species, is so distinctive in possessing an "outer utricule or nut" surrounding the oogonium that a rank equivalent to that of the Characeae could scarcely be questioned.

It is evident that Pia considered the sinistrally spiraled Charophyta as a more or less unified group regardless of the number of enveloping cells. Although one might question the advisability of raising *Palaeochara* Bell to a rank equivalent to the Characeae because of an additional cell in the oogonium wall, probably no investigator working with living or fossil charophytes would suggest that variations in the number of enveloping cells was not of high systematic value. Furthermore, probably all workers on living

or fossil charophytes would agree that the sinistral ascent of the enveloping cells definitely separates *Palaeochara* Bell from the group of dextrally spiraled trochiliscids although both of these, as known at present, have more than five enveloping cells.

The difficulties to be encountered in an attempt to arrange living and fossil charophytes within a single classification are evident, inasmuch as among the living forms several groups have not acquired the ability to secrete calcium carbonate and the nature of their ancestors is largely conjectural. It is only logical to assume that the fossil representatives with calcified structures also had a considerable history as noncalcified organisms. The inter-relationships of living and fossil forms is further complicated in that the classification of the living charophytes depends largely on noncalcified structures that are seldom preserved in the fossil state.

Although the geologic history of the charophytes contains many gaps it is sufficiently complete to illustrate certain trends in the development of the group. These furnish the basis for a tentative classification.

Throughout the development of the charophytes there has been a marked tendency for simplification and reduction of parts. The geologic range of the Trochiliscaceae is short, but within this time there was a reduction in the number of enveloping cells. Karpinsky, working with representatives from the Lower Devonian of Europe, found that most of the individuals possessed eight or nine spiral units, but several possessed ten. Knowlton (19) described a collection of Trochiliscaceae from the Falls of the Ohio as dominantly ten spiraled forms. My own observations have indicated that in the Devonian deposits the nine spiraled forms rank first in abundance, the eight spiraled forms second, and the ten spiraled forms third. Only two specimens with seven spirals (aside from a few problematic forms described herein as *Trochiliscus* sp.) have been collected from the Devonian, in this case from the Upper Devonian. In the Sylamore (Kinderhookian) nine and eight spiraled forms were still the most abundant, the eight spiral almost as numerous as the nine; only a few ten spiraled forms were observed, and the forms with seven spirals, although not numerous, are more abundantly represented. Considering the direction of the trend it is quite possible that, if Trochiliscaceae of later ages are found, the number of spiral units will have been reduced to five, as is the case of the sinistrally spiraled charophytes. Five enveloping cells seems to be the minimum and ten the maximum.

The sinistrally spiraled Charophyta are represented from the Pennsylvanian to the present. Although five enveloping cells is undoubtedly the dominant number in this group one well defined occurrence, *Palaeochara acadica* Bell from the "Coal Measures" of Nova Scotia, has six spiral units. It is feasible to assume that this group had undergone considerable reduction in parts before they acquired the ability to calcify, and a certain reduction is observable from *Palaeochara acadica* to the five spiraled forms. That a reduction in the number of enveloping cells has been the rule in the Charophyta is further evidenced by the living families, Chareae and Nitelleae. The oogonium wall of the latter consists of fifteen cells—five enveloping and ten coronula—and the oogonium wall of the Chareae consists of ten cells—five enveloping and five coronula cells. The Chareae is to be considered the more highly developed if we assume, as seems logical, that the acquisition of the ability to secrete calcium carbonate is an index of advancement. The Chareae are, for the most part, calcified forms and the Nitelleae are dominantly noncalcified.

On the basis of those distinct trends toward reduction in parts I am venturing to point out what seems to be a logical classification to include the three diversified groups, the Sycidiaceae, the Trochiliscaceae, and the Characeae. This

scheme is not entirely original as it was implied, at least, in Karpinsky's "Die Trochilisken."

Of these three groups the Sycidiaceae is evidently the most primitive and most nearly representative of the ancestral condition. As stated above in the section on "Morphology," there is evidence to indicate that the large number (16, 18, 20) of meridional units in the Sycidiaceae were developed by the vertical division of a small number (8, 9, 10) of bud cells separating from the noncalcified node-cell. As the largest number of meridional units in the Sycidiaceae is twenty—probably originating from ten bud cells—and the largest number of spiral units in the Trochiliscaceae is ten, it may be assumed that the original number of cells budding from the node-cell of the primitive charophyte oogonium was ten. In the Sycidiaceae these ten cells elongated upwards and divided vertically to form twenty meridional units enveloping the oosphere. Early in charophyte history three distinct trends in development started. One group, the Sycidiaceae, continued with the meridional units and in the Devonian acquired the ability to calcify. Another group, the Trochiliscaceae, reduced the number of meridional units through failure of the primary units to divide vertically. Accompanying this reduction of meridional units there was a lengthening and twisting (dextrally) of the enveloping cells. By virtue of this new cell shape the oospore, without reduction in size, was still completely covered by the lessened number of enveloping cells. The third group, the Characeae, also reduced the number of meridional units and in this case the enveloping cells twisted sinistrally. It is possibly only a coincidence that one group developed a dextral twist and the other a sinistral twist, but it should be noted that the sinistrally spiraled group is dominantly a fresh water plant and the other marine. It is probably only a coincidence that the Sycidiaceae and the Trochiliscaceae acquired the ability to secrete calcium carbonate as a support and became represented as fossils long before the Characeae acquired the same habit. Although the record of the Trochiliscaceae is lost before the appearance of the Characeae there is little possibility that the dextral twist of the enveloping cells of the Trochiliscaceae was reversed to produce the sinistral twist of the Characeae.

In brief, there seems to be three distinct groups within the Charophyta which should be recognized as of equal —perhaps ordinal or class—rank, the Characeae, the Trochiliscaceae, and the Sycidiaceae. It is doubtful that *Palaeochara* Ball stands in the direct developmental line of the present day Characeae as many living forms are noncalcified, but it undoubtedly belongs to this group. The accompanying chart, figure 2, illustrates graphically my opinion as to the general relationships between fossil and living charophytes.

Authors describing charophyte spores of Cretaceous or later age often mention that there is very little variation on which to base specific definitions, and in the living forms there may be but slight differences between the spores of different species or even different genera. In working with representatives of the genus *Trochiliscus* I have found just the opposite to be the case and have had considerable difficulty in distinguishing between variations that might occur in one species and variations that should be of specific value. Karpinsky, in "Die Trochilisken" lists the following as characters considered of specific value: (1) the number of spiral ribs, (2) the shape, (3) the size, and (4) the ornamentation, or comparative width of the ridges and furrows. In this work all of the above characters have been considered and in addition: (5) constant variations in the part of a complete turn about the oogonium made by the spiral cells, and (6) the consistent absence or presence of coronula cells.

The number of spiral units in the Trochiliscaceae varies from seven to ten with the majority of forms possessing

nine. Karpinsky defines one species with a much larger number (18) but as explained above under "Morphology" this probably is a calcification stage of the nine-celled group. A variation in the number of enveloping cells in the Characeae is considered of high classificatory value and the single occurrence of a six-celled form has caused a new subfamily to be erected for its reception. Undoubtedly the charophytes were widely distributed in the Devonian and Lower Mississippian seas and all evidence indicates that they were even more differentiated than are the living representatives of the group. If it were possible to study the plants in their entirety, it is probable that the number of spiral cells in the oogonium wall would be of ordinal or family value. But in the present state of our knowledge of the group there seems to be little value in establishing a complicated classification. The number of enveloping cells of the oogonium is a distinct morphological character and I have considered it a specific character of primary rank.

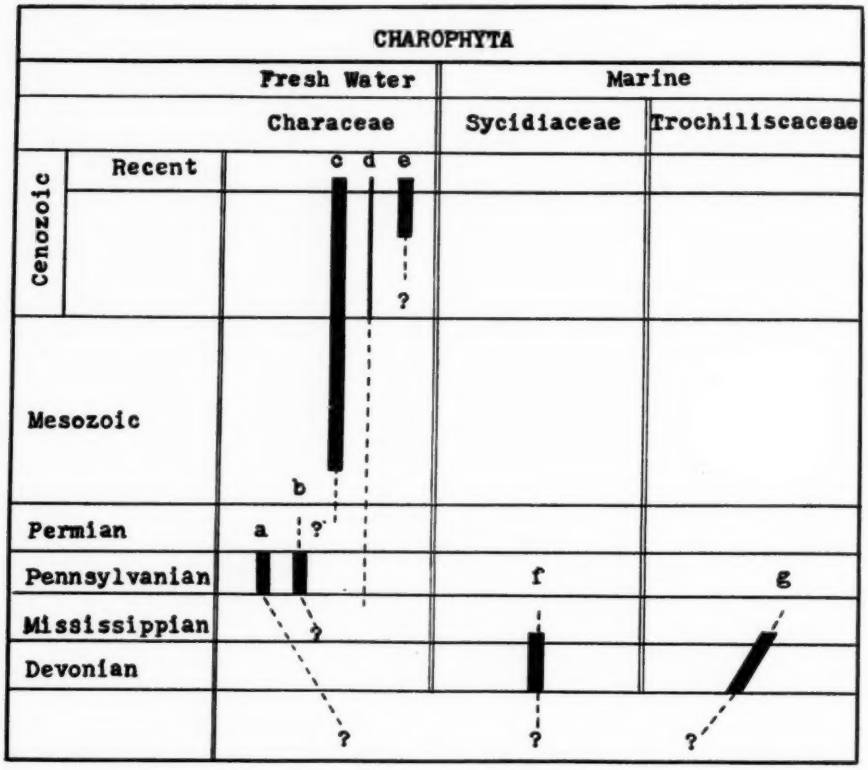


FIG. 2.—Chart to show the geologic distribution and relationships of the Charophyta. *a*, Palaeochara; *b*, undescribed collection of five spiraled Pennsylvanian Charophyta; *c*, Chareae; *d*, *Nitella*; *e*, *Tolypella*; *f*, Sycidiaceae; *g*, Trochiliscaceae. Heavy lines indicate calcified record; narrow continuous lines indicate probable existence as noncalcified organisms. The five spiraled Pennsylvanian record and Triassic record are of specimens recently described in the American Journal of Science.

The remarkable thing about the varia-

tions in the number of spiral ridges is that when large collections are studied in which all four numbers are represented this is the only constant variation. For example, in the Sylamore sandstone at Williamsburg, Missouri, great quantities of Trochiliscaceae have been collected in which the eight or nine spiraled bodies are abundantly represented and seven and ten only sparsely. This, however, aside from the different stages of calcification represented, is the only variation. The spiral ridges all make approximately a fourth turn about the oogonium. The equatorial angle displays only slight variations within each group. The Sylamore Trochiliscaceae agree n shape and size. All are coronulate. In the collection made by the late Doctor Thomas from the *Devonocidaris jacksoni* zonule of the Cerro Gordo member of the Hackberry stage (Devonian) of Iowa essentially the same conditions are present. The spiral ridges make approximately a half turn about the oogonium. The equatorial angle is approximately the same on all individuals. They agree in shape and size and all but one are coronulate. This non-coronulate species has only eight spiral ridges and is the most abundant form represented in this collection. All Snyder Creek specimens studied have nine spiral ridges. All Bell shale forms have nine spiral ridges. The question arises as to whether, in the case of the Iowa and Sylamore trochiliscids, spores with a variable number of cells might have developed on the same plant. This hardly seems plausible when one considers the constancy of the number of cells on post-Pennsylvanian Charophyta, on the characteristic noncoronulate Iowa Devonian specimens, and on the Bell shale and Snyder Creek specimens.

Furthermore, there is no evidence on the hundreds of specimens examined of cells becoming subordinated and partly suppressed as should be the case were spores with different numbers of spiral ridges on the same plant.

Karpinsky found that variations in shape were quite diagnostic and of great value in distinguishing between species belonging to the genus *Trochiliscus*. The North American individuals are all nearly spherical and it has been found impossible to differentiate between species by this character. There are slight variations in shape and seemingly typical shapes for each species defined, but examinations of large collections have indicated that there is as much variation within a species as between species.

Size is a character that is easy to recognize and one that is relatively constant. Some species are typically small and others typically large but the great majority of the Trochiliscaceae have practically the same dimensions.

The comparative width of the ridges and furrows has been interpreted as representing successive stages of calcification and can be used as a specific distinction only in cases where a large number of forms have reached approximately the same stage with no later stages represented.

There is but little variation in the relative length of the spiral cells and the part of a complete turn they make around the oogonium. The spiral ridges of *Trochiliscus lemoni* (Knowlton) make approximately a complete turn. Most of the individuals from the Devonian of Iowa make a half turn. Other Trochiliscaceae make from a fourth to a third. It might be expected that the number of spiral cells would influence this factor but in so far as I can determine it is of little importance.

Although the calcification of the coronula cells may be considered of greater than specific value, I have regarded it as a further trend toward calcification that might well be developed independently among species of different genera.

Only two species of the genus *Sycidium* have been recognized in North America and they differ so markedly in shape, size, and number of meridional units that a consideration of specific characters seems unnecessary.

DESCRIPTIVE TERMINOLOGY

For descriptive purposes the trochiliscids have been oriented in accordance with the position they are assumed to have had on the living plant; with the attached end considered as the base and the free end the summit. If the coronula cells are present they are always superior in position. If the coronula cells are absent the larger of the polar openings is considered the summit. For illustrations of orientation and descriptive terminology see Plate 9, figures 13*a–b*.

In the descriptions of the trochiliscids a distinctive terminology is employed to which I have found it necessary to add a few new features. For uniformity in descriptions possibly a statement of usage will be of value.

Basal opening.—The small perforation in the center of the base of the oogonium—in the living plant occupied by the node-cell.

Cellular furrows.—If the enveloping cells are only partially filled with calcium carbonate they are represented on the fossilized oogonia as furrows.

Cellular ridges.—If the enveloping cells were completely calcified they are represented on the fossilized oogonia as broad, rounded ridges.

Coronula.—One or two tiers of small cells resting on the apical ends of the enveloping cells and forming a more or less erect elevated ring around the summit. Not calcified in sinistrally spiraled spores and not preserved on post-Mississippian forms. In several species of the Trochiliscaceae the cells did calcify and are preserved.

Coronulate.—A term used to express the presence or direct indication of the former presence of coronula cells on the fossil oogonia.

Enveloping cells.—The spirally twisted (meridional in Sycidiaceae) cells arising from the node-cell and elongating to form a cover or envelope for the oosphere. The deposition of calcium carbonate takes place within these cells.

Equatorial angle.—The angle formed by the enveloping cells with the horizontal as they cross the equator of the specimen.

Intercellular furrows.—If the calcification of the enveloping cells builds up higher than the lateral contacts of adjoining cells the area represented by the lateral sutures becomes furrows.

Intercellular ridges.—In the first stages of calcification the enveloping cells build up along their concave inner walls adjoining the oospore. On disappearance of the protoplasmic contents the cells become represented by *cellular furrows* and the lateral sutures of the enveloping cells by ridges.

Meridional units.—The enveloping cells of the Sycidiaceae—twisted neither dextrally nor sinistrally.

Noncoronulate.—A term used to describe the fossil oogonia on which there is no evidence of coronula cells. *It does not mean that coronula cells were not present on the oogonia of the living plants* but only that they are not preserved.

Oogonium.—The female reproductive organ of the Charophyta—the only part of the plant represented in the trochiliscids.

Oosphere.—The nonfertilized egg cell of the living Charophyta.

Oospore.—The fertilized egg cell of the living Charophyta.

Oospore membrane.—The hardened outer covering of the oospore, determined by Nordstedt to be of suberin and silicic acid—the only part of the oospore preserved in fossils. Represented in silicified trochiliscids as an inner sac of cryptocrystalline silica.

DESCRIPTIONS OF GENERA AND SPECIES

CHAROPHYTA

Family TROCHILISCACEAE[5] Karpinsky

Genus TROCHILISCUS Karpinsky

Globular oogonia composed of from ten to seven enveloping cell units, possibly less, originating around a small basal

[5] Written "Trochiliscidae" by Karpinsky.

opening and ascending dextrally with a fairly uniform spiral twist to the opposite pole on the oogonia where the apical ends surround the summit orifice. Each spiral unit expressed on the outer surface of the oogonia by a broad, gently rounded ridge, usually with a median groove, bounded on each side by furrows; or by a comparatively broad furrow bounded laterally by ridges. Oospore membrane in the mature oogonia usually contracted but occasionally in contact with the inner surface of the oogonia walls.

The first undoubted mention of representatives of this genus was made by Ehrenberg (10) in 1859 when he referred them, along with members of the previously described *Sycidium* G. Sandberger (1849), to the foraminiferal genus *Miliola* as *M. panderi*. Three years before Ehrenberg's article appeared, Pander (26, p. 17) had suggested the name "Trochilisken" for a group of small bodies that he had discovered in association with the Devonian fish remains of Russia. Pander's abbreviated description could be applied to either the spiral bodies or to the longitudinally ridged *Sycidiaceae*, and in his second reference to the "Trochilisken" in 1857 (27) he was evidently referring to representatives of *Sycidium*. In 1880, Williamson (48) proposed the generic name *Calcisphaera* for the group of problematic organisms from the Carboniferous of Wales and referred a number of spiral bodies from the Kelly's Island Devonian to it as *Calcisphaera robusta*. The spiral bodies of the Devonian are evidently not congeneric with the problematic forms from the Carboniferous of Wales. As the name *Calcisphaera* was proposed for the latter the spiral bodies should be given generic distinction. This is true in spite of Miller's (24) proposal that *Calcisphaera robusta* Williamson be designated as the genotype of *Calcisphaera*. In 1886, Ulrich (45) proposed the generic name *Moellerina* for a group of spiral organisms from the Devonian at the Falls of the Ohio, but in his illustrations the spiral ridges ascend sinistrally. As the type specimens of *Moellerina greenei* have been lost the name cannot be used for dextrally spiraled oogonia.

In 1906, Karpinsky (16) included all the dextrally spiraled oogonia under the generic name *Trochiliscus* Pander. As Pander proposed a group name "Trochilisken" under which he included the previously described *Sycidium* G. Sandberger and possibly the spiral bodies, but did not follow the rules of binominal nomenclature, it seems fitting that Karpinsky should receive the credit for the name *Trochiliscus*. Karpinsky defined only two species and the first of these, *Trochiliscus ingricus* Karpinsky from the Devonian of U.S.S.R., is here designated the genotype.

Karpinsky's generic description states that members of the genus *Trochiliscus* may have eight or nine to eighteen spiral ridges, with few deviations from these numbers. In working with the abundant and most excellently preserved representatives of this genus in North America, especially those forms from the Iowa Devonian and Missouri Kinderhookian localities, it has been noted that the bodies are always composed of from seven to ten enveloping cell units. At a certain stage of calcification the lateral walls of the cell units are built up above the intercellular ridges leaving the center of each cell depressed so that each spiral unit is represented by two distinct ridges (see Pl. 11, fig. 12). Therefore, any of these bodies with a certain degree of calcification may possess just twice the number of ridges that it has spiral units.

TROCHILISCUS LEMONI (Knowlton) Karpinsky

Plate 9, figures *6a–c*

Calcisphaera lemoni KNOWLTON, *1889*, Am. Jour. Sci., 3d ser., vol. 37, pp. 202–209, text figs. 1–3.

Trochiliscus lemoni (Knowlton) KARPINSKY, *1906*, Mémoires du Comité Géologique, Nouvelle série, Livraison 27, pp. 113–114, 123, text fig. 19.

The organisms under consideration are minute, spirally grooved bodies from 1.50 to

1.80 mm. long and about 1.70 mm. broad. They have been hollow spheres and the now solid interior has probably been infiltrated through the very small orifice at one extremity. The outer wall has been moderately thick and when broken away, leaves impressed upon the nucleus, lines indicating the position of the spirals. The "shell" breaks away very easily and it is a matter of some difficulty to obtain absolutely perfect specimens from the matrix. I am unable to detect structure in the outer wall. Ten, or perhaps rarely nine, spirals (cells?) have entered into the composition of the "shell" (sporostegium?). About eight turns of the spiral are visible in lateral view (Knowlton).

Occurrence.—Jeffersonville (Onondaga) limestone at the Falls of the Ohio, Louisville, Kentucky.

Types.—The type material in the United States National Museum cannot be located.

T. lemoni is by far the largest trochiliscid recorded, no other species averaging more than 1.0 mm. in width and height.

EXPLANATION OF PLATE 9

FIGS. 1*a–d*—*Sycidium reticulatum* G Sandberger, approx. ×16.5. After Sandberger. 1*a*, lateral view; 1*b*, longitudinal section; 1*c*, cross-section; 1*d*, basal view.

2*a–f*—*Moellerina greenei* Ulrich, approx. ×16.5. After Ulrich, 2*a*, summit view; 2*b*, inner chamber with fragment of the outer shell; 2*c*, lateral view; 2*d*, lateral view with a portion of the outer shell broken away; 2*e*, longitudinal section showing two apparent chambers; 2*f*, broken specimen with faint indication of pores in the wall.

3*a*, *b*—Quenstedt's illustration of "Trochilisken," enlarged. After Karpinsky.

4*a–c*—*Saccammina* (*Calcisphaera*) *eriana* Dawson. From Karpinsky after Dawson. 4*a* above, actual size, 4*a* center, enlarged, showing ornamentation, 4*a* below, enlarged, showing the opening; 4*b*, greatly enlarged cross section of part of the shell; 4*c*, enlarged section.

5—*Trochiliscus robustus* (Williamson), enlarged. From Karpinsky after Williamson.

6*a–c*—*Trochiliscus lemoni* (Knowlton), approx. ×16.5. After Knowlton. 6*a*, lateral view; 6*b*, polar (summit?) view; 6*c*, internal mold.

7—*Chara hispida*, mature antheridium, enlarged. From Groves and Bullock-Webster after Prosper. Courtesy of the Ray Society.

8*a*, *b*—*Sycidium*, restored oogonia, enlarged. After Karpinsky. 8*a*, nodose oogonium with convex cells; 8*b*, pitted oogonium.

9*a–f*—*Chara vulgaris*, diagrams showing development of oogonium, enlarged. From Groves and Bullock-Webster after De Bary and Migula. Courtesy of the Ray Society. 9*a*, first division of cell; 9*b*, division of periphery of node-cell into five cells forming the enveloping cells; 9*c*, further development of the five enveloping cells; 9*d*, formation of a horizontal septum dividing enveloping cells into two stages—the upper forming the coronula; 9*e*, further development of enveloping cells, showing their lengthening and spiral growth; 9*f*, oogonium approaching maturity. Explanation of parts: *a*, oosphere; *b*, node-cell; *c*, enveloping cell; *d*, cells of coronula; *e*, turning cell.

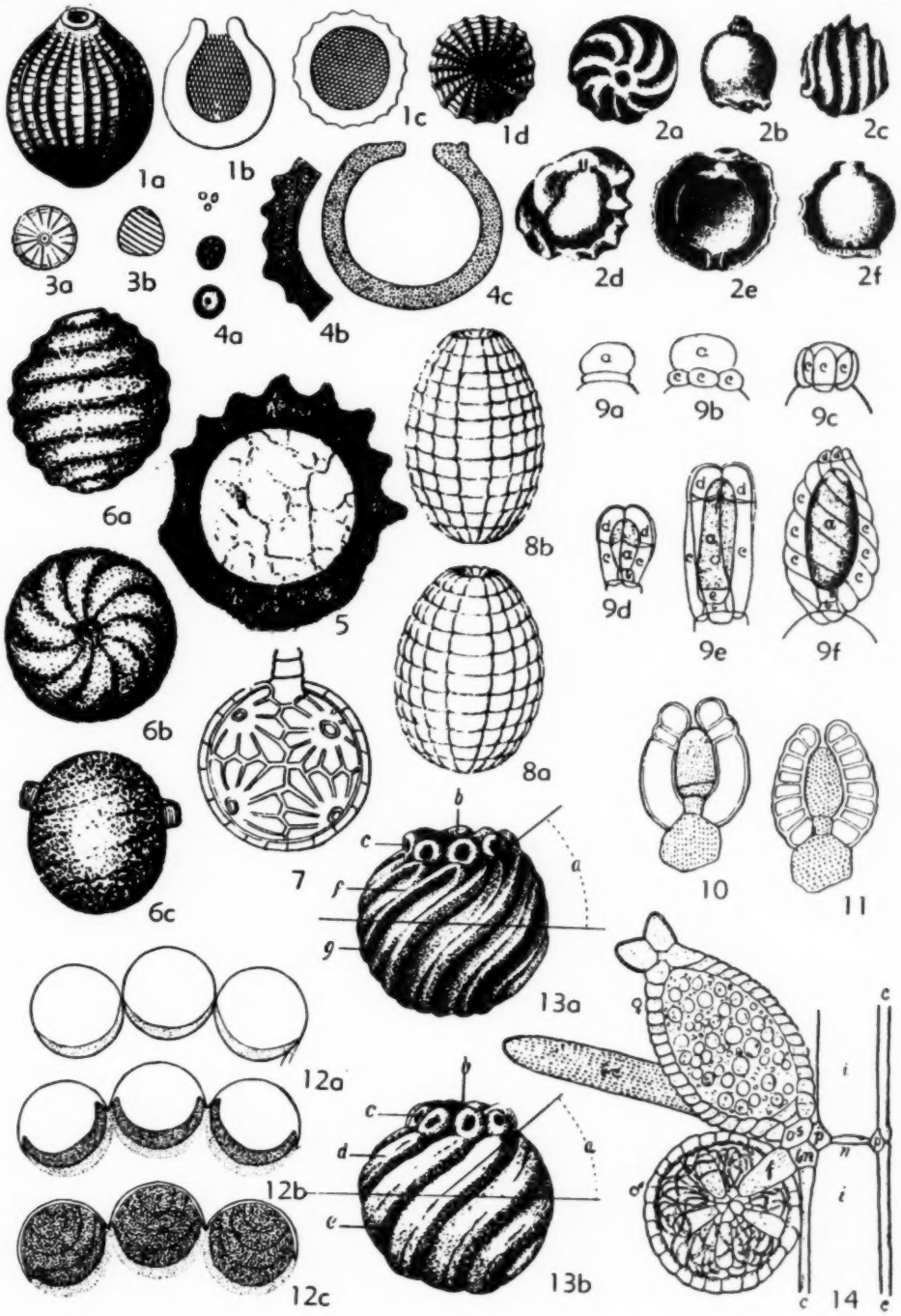
10—*Nitella*, cross-section of a young oogonium, enlarged. From Karpinsky after Sachs.

11—*Sycidium*, diagrammatic cross-section of oogonium, enlarged. After Karpinsky.

12*a–c*—Diagrammatic sketches to show calcification of the enveloping cells in Charophyta oogonia. 12*a*, first deposition of calcium carbonate on the concave inner wall of the enveloping cells; 12*b*, mature oogonium in which the lateral walls of the cells have broken down and the calcium carbonate contents of adjoining cells united to form a lime-shell; 12*c*, mature oogonium in which the calcium carbonate has almost completely filled the cells.

13*a*, *b*—Trochiliscid oogonia (diagrammatic in part) to illustrate orientation and descriptive terminology. Explanation of parts: *a*, equatorial angle, *b*, summit orifice; *c*, coronula cells; *d*, cellular ridge; *e*, intercellular furrow; *f*, intercellular ridge; *g*, cellular furrow.

14—*Chara fragilis*, showing position of reproductive organs, enlarged. From Groves and Bullock-Webster after Strasburger. Courtesy of Ray Society. Explanation of parts: *n*, central cell of node; *i*, internodal cells; *bn*, basal nodal cell; *f*, flask-cell of antheridium; *p*, peripheral cells; *c*, cortical cells; *os*, stalk cell of oogonium; *bc*, bract-cell.



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It has been described as typically having ten spiral ridges of which about eight are visible in a side view. Knowlton's figures and comparison of his specimens with those described as *Chara* by Meek (21, 22), indicate that spiral ridges make approximately a complete turn around the oogonium. Knowlton's illustrations indicate that *T. lemoni* has broad, rounded spiral ridges but no differentiation at the summit into coronula cells. This is remarkable in view of the fact that in all specimens with broad spiral ridges examined, coronula cells have been noted or cavities around the summit orifice indicate their accidental loss.

It may be noted that *T. lemoni* comes from the same locality and probably the same horizon as the forms described by Ulrich (45) as *Moellerina greenei*.

TROCHILISCUS ROBUSTUS (Williamson) Karpinsky

Plate 9, figure 5

Calcisphaera robusta WILLIAMSON, *1880*, Philos. Trans. Roy. Soc., vol. 171, part 2, p. 523, pl. 20, fig. 81.—MILLER, *1889*, North American Geology and Paleontology, p. 155.

Saccammina? (*Calcisphaera*) *eriana* DAWSON, *1883*, Canadian Naturalist and Quart. Jour. Sci., new ser., (no. 10), pp. 5–8, text fig. 1.

Trochiliscus robustus (Williamson) KARPINSKY, *1906*, Mémoires du Comité Géologique, Nouvelle série, Livraison 27, p. 116, text fig. 21.

Although I have examined three collections of trochiliscids from the Columbus limestone near Sandusky, Ohio, the locality from which Williamson and Dawson obtained their material, I have been unable to identify *T. robustus*. The descriptions given by both Williamson and Dawson were generalized and were for the purpose of announcing a new discovery rather than describing specific characters. I have recognized three species from this locality, *T. bilineatus*, *T. liratus*, and *T. bellatulus*. Any one of these may be the same as *T. robustus*. I have not been able to locate the types of that species.

TROCHILISCUS DEVONICUS (Wieland) Peck

Plate 12, figures 14–21

Chara devonica, WIELAND, *1914*, Am. Mus. Nat. Hist., Bull., vol. 33, p. 245.

Oogonium noncoronulate, spherical, of medium size, ranging from 0.6 mm. to 0.8 mm. in height, slightly wider than high, greatest transverse diameter near mid-height. Base and summit shallowly truncate. Ridges intercellular, nine, completing about a half turn around the oogonium, recurving toward the summit to an almost vertical position, equatorial angle about 30°. The ridges are extremely sharp and narrow, and are separated by wide, shallow cellular furrows. Summit orifice surrounded by low ridge connecting apical ends of the spirals. Oospore membrane thick and usually slightly contracted.

Occurrence.—Jeffersonville limestone (Onondaga), Falls of the Ohio, Louisville, Kentucky; Snyder Creek shale, Snyder Creek, Callaway County, Missouri.

Plesiotypes.—Catalog number 39151, United States National Museum.

The above description is based upon four silicified specimens from cherty limestone at the Falls of the Ohio and a large number of poorly preserved calcite specimens from the Snyder Creek shales. A few of the Snyder Creek forms have a greater equatorial angle than the plesiotypes and several have slightly broader ridges. The latter feature is interpreted as being caused by the difference in preservation.

In 1886 Ulrich described and figured a collection of spiral bodies from the Onondago limestone at the Falls of the Ohio as a new genus and species of Foraminifera, *Moellerina greenei*. In Ulrich's illustrations the spiral ridges ascend sinistrally and the equatorial angle is very low. The sinistral direction of the spiral ridges is a characteristic feature of modern Charophyta, but with the one exception, has never been noted below the Pennsylvanian. *M. greenei* resembles *T. devonicus*, as herein defined, only in the type of preservation. The oogonium wall and the slightly contracted oospore

membrane are silicified in both and the interior is hollow, as is often the case with silicified fossils in chert. Unfortunately, Ulrich's types have been lost and it is impossible to verify the belief that his specimens were misrepresented in the illustrations.

In 1914, Wieland recorded an occurrence of spirally sculptured forms from the Snyder Creek shales of Callaway County, Missouri, under the name *Chara devonica*. Wieland neither described nor figured the specimens and at the present time is unable to locate them. Inasmuch as extensive collecting by the writer in the same locality from which Wieland's specimens came has yielded only one species it is taken for granted that it is the form designated by Wieland as *Chara devonica*.

TROCHILISCUS DECACOSTATUS Peck, n. sp.
Plate 12, figures 4–9

Oogonium coronulate, subspherical, medium large, averaging about 0.8 mm. in height, wider than high, with greatest transverse diameter about mid-height. Base and summit deeply truncate, the summit more deeply than the base. Ridges intercellular, ten, completing about a fourth turn around the oogonium, equatorial angle 30° to 35°. The ridges are flat and of uniform medium width from base to summit. Intercellular furrows narrow and deep. Coronula cells ten, deeply concave on outer surface, corresponding in position with the cellular furrows and forming a sub-erect parapet-like ring around the summit orifice, the inner surface of the coronula ring constituting a broad funnel to the opening. Oospore membrane unknown.

Occurrence.—Sylamore (Basal Mississippian); Williamsburg, Missouri.

Cotypes.—Catalog number 31003–1, University of Missouri.

This species is comparatively rare in the Williamsburg locality of the Sylamore, only ten specimens having been collected from the material that yielded hundreds of representatives of other species. None of the specimens of *T. decacostatus* has cellular ridges and only the first two stages of calcification have been noted. In some of the specimens there has been an abnormal development of two adjoining cells, and they stand considerably above the general surface of the specimen (Pl. 12, fig. 9).

Trochiliscus lemoni (Knowlton) Karpinsky, a ten spiral species from the Devonian at the Falls of the Ohio is much larger and the cells make a complete turn about the oogonium. *Trochiliscus bellatulus* Peck from the Onondaga at Marblehead, Ohio, is noncoronulate. *Trochiliscus meeki* Peck from the Devonian of Iowa is smaller, the base is not so deeply truncate, and the spiral ridges are much smaller.

TROCHILISCUS LATICOSTATUS
Peck, n. sp.
Plate 11, figures 1–23

Oogonium coronulate, subspherical, large, ranging from 0.8 mm. to 1.0 mm. in height, typically wider than high, with greatest transverse diameter near mid-height. Base and summit horizontally truncate, summit more deeply than base. Ridges cellular, nine, completing from a fourth to a half turn around the oogonium, equatorial angle from 35° to 40°. The ridges are broad and flat or slightly concave near the base and become more narrow and convex toward the summit. Intercellular furrows narrow or of medium width, and shallow. Coronula cells nine, deeply concave on outer surface, corresponding in position with the cellular ridges and forming an erect to sub-erect parapet-like ring around the large summit orifice, the inner surface of the coronula ring constituting a broad funnel to the opening. Oospore membrane usually contracted, sometimes folded, but occasionally in contact with the inner wall of the oogonium.

Occurrence.—Sylamore (Basal Mississippian); Williamsburg, Missouri.

Holotype.—Catalog number 31000–1, University of Missouri. *Paratypes.*—

Catalog number 31000–2, University of Missouri.

The superficial appearance of specimens referred to this species varies greatly, corresponding to the different degrees of calcification in the enveloping cells. An almost perfect and imperceptible gradation can be traced from forms with broad, deep cellular furrows and sharp, narrow inter-cellular ridges to those with broad, convex cellular ridges and narrow intercellular furrows. The latter form is considered the typical and most highly developed representative of the species and has been used as a basis for the above description. However, other stages of calcification are abundantly represented.

The first stage of calcification is represented by specimens with wide cellular furrows and sharp, narrow intercellular ridges. The height of the oogonium is usually equal to the width, instead of slightly less as described above, a difference caused by the convexity of the cells of the forms described as typical. The coronula cells are not as well developed nor as easily differentiated in this group as in the typical specimens, and it is often necessary to etch the specimens with acid to bring out the suture between the coronula and enveloping cells.

At a further stage of calcification the cellular furrows are slightly narrowed and the intercellular ridges correspondingly widened. There has been a further coalescence of the mineral content of the adjoining cells and the last layer of material deposited within one cell is separated from that of the adjoining cell by a very slight furrow in the middle of the intercellular ridge. These specimens very closely resemble *Trochiliscus bilineatus* Peck but are larger and differ in the inclination of the spiral ridges.

With increasing calcification the cellular furrows become more narrow and shallow and the intercellular ridges correspondingly wider. A further coalescence of the mineral content of adjoining cells along the lateral sutures created wide, flat or slightly concave intercellular ridges on which the last layer of calcium carbonate deposited within the cell is differentiated from the coalesced material by a well defined line.

Increasing calcification causes each of the nine spiral units to be represented by two ridges, further deposition in the enveloping cell having built up the lateral edge of the cellular furrows above the intercellular ridges. In this way the oogonium has acquired eighteen spiral ridges with nine narrow cellular furrows

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EXPLANATION OF PLATE 10

All specimens enlarged twenty diameters

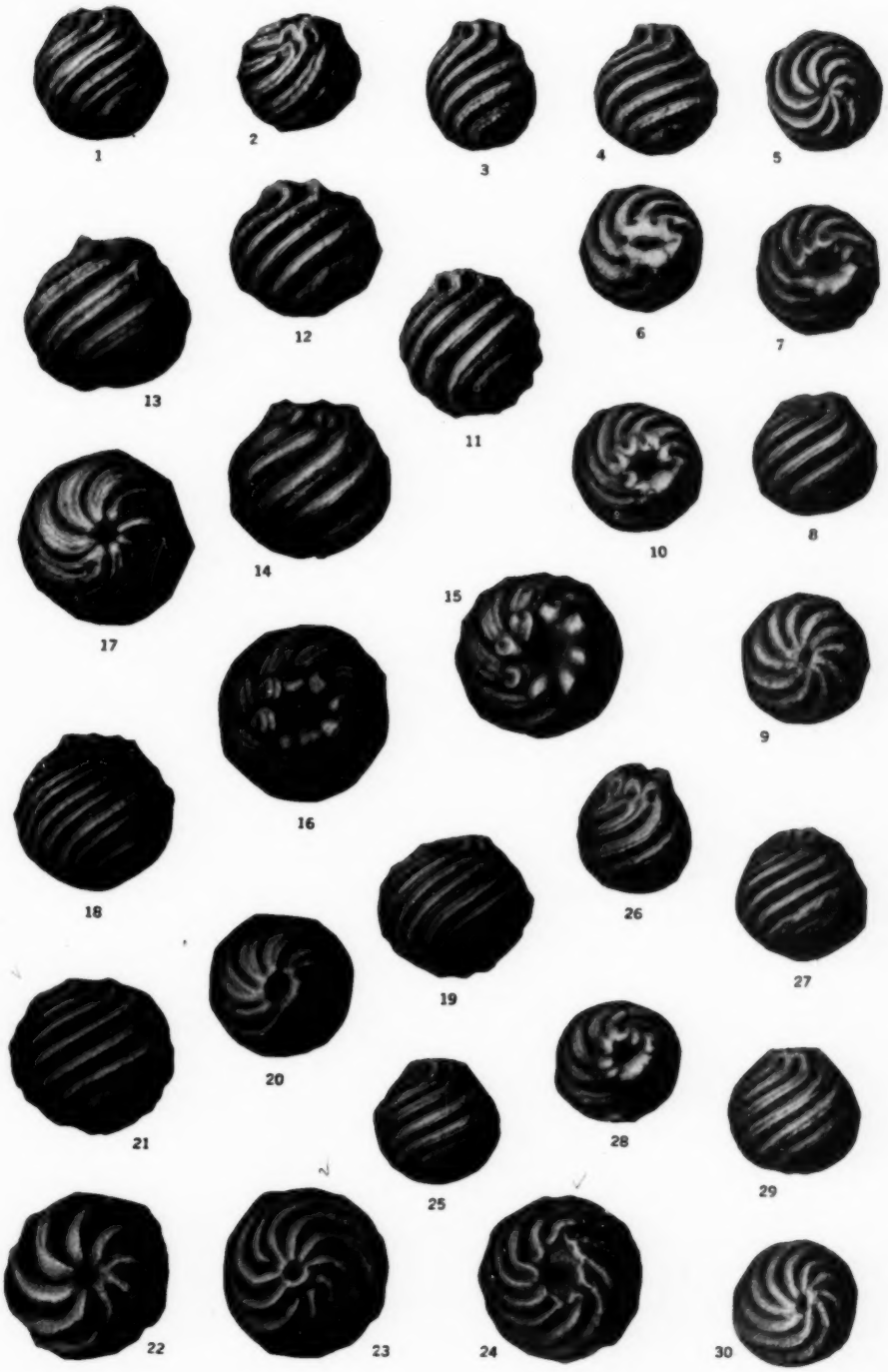
FIGS. 1–6—*Trochiliscus liratus* Peck, n. sp. 1–3. Lateral view of three paratypes; 1, specimen with wide intercellular ridges; 2, specimen inclined to show position of coronula cells; 3, exceptionally slender specimen. 4–6, Lateral, basal, and summit views of holotype. (p. 113)

7–10—*Trochiliscus meeki* Peck, n. sp. 7, Summit view of paratype. 8–10, Lateral, basal, and summit views of holotype. (p. 112)

11–20, 22—*Trochiliscus octocostatus* Peck, n. sp. 11–13, Lateral views of three paratypes showing first stages of calcification. 14–15, Lateral and summit views of holotype. 16–20, 22, Summit, lateral, and basal views of paratypes; 16, summit of a cellular ridged specimen; 17, basal view showing cellular ridges with shallow median groove; 18, 19, lateral view of specimens with both cellular and intercellular furrows—from a basal view they would appear to have sixteen ridges; 20, basal view showing cellular furrows almost completely filled out; 22, basal view of a specimen with sharp intercellular ridges. (p. 111)

21, 23, 24—*Trochiliscus bellatulus* Peck, n. sp. Holotype. (p. 115)

25–30—*Trochiliscus bilineatus*, Peck, n. sp. 25–27, Lateral views of three paratypes; 25, lateral view of a normal specimen; 26, a specimen inclined to show position of coronula cells, 27, a specimen with sharp intercellular ridges. 28–30. Summit, lateral and basal views of holotype. (p. 113)



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and nine narrow intercellular furrows. This stage grades into the cellular ridged form described as typical.

The union of the mineral content of adjoining cells varies with the individual, and some of the specimens in which the enveloping cells were completely calcified have only narrow coalesced zones (Pl. 11, fig. 20).

T. laticostatus is the most abundant trochiliscid in the Sylamore sandstone at Williamsburg, Missouri. It is easily distinguished by the number of spiral ridges, the well-developed cellular ridges, and the large size.

TROCHILISCUS OCTOCOSTATUS Peck, n. sp.
Plate 10, figures 11–20, 22

Oogonium coronulate, subspherical, large, ranging from 0.7 mm. to 1.0 mm. in height, wider than high, with greatest transverse diameter at or slightly below mid-height. Base and summit horizontally truncate, summit more deeply than base. Ridges cellular, eight, completing from a fourth to a half turn around the oogonium, equatorial angle from 35° to 40°. The ridges are broad and flat or slightly concave near the base and become more narrow and convex toward the summit. Intercellular furrows narrow or of medium width, and shallow. Coronula cells eight, deeply concave on outer surface, corresponding in position with the cellular ridges and forming an erect to sub-erect parapet-like ring around the large summit orifice, the inner surface of the coronula ring constituting a broad funnel to the opening. Oospore membrane usually contracted, sometimes folded, but occasionally in contact with the inner wall of the oogonium.

Occurrence.—Sylamore (Basal Mississippian); Williamsburg, Missouri.

Holotype.—Catalog number 31002–2, University of Missouri. *Paratypes.*—Catalog number 31002–3, University of Missouri.

T. octocostatus closely resembles *T. laticostatus* Peck, differing only in the number of spiral ridges, and in having a greater width in comparison to the height. The latter distinction is not sufficiently consistent to differentiate the two species. As in *T. laticostatus*, the superficial appearance of specimens referred to this species varies greatly, and there is a gradual transition from the forms with wide cellular furrows and sharp intercellular ridges to those in which the broad ridges are cellular and the narrow furrows intercellular. There is a gradual widening of the intercellular ridges and a corresponding narrowing of the cellular furrows as further layers of calcium carbonate are deposited within the cells until finally the cell deposition builds up above the intercellular ridges.

T. octocostatus ranks second in abundance in the Sylamore at the Williamsburg locality, being surpassed only by *T. laticostatus*.

T. liratus Peck, of Iowa, the only other eight spiraled coronulate trochiliscid recorded from North America, is smaller and more nearly globular than *T. octocostatus*, and evidently did not reach the stage of complete calcification of the enveloping cells.

TROCHILISCUS SEPTEMCOSTATUS Peck, n. sp.
Plate 12, figures 25–30

Oogonium coronulate, spherical, medium large, averaging about 0.8 mm. in height, wider than high, with greatest transverse diameter near mid-height. Base horizontally truncate. Ridges cellular, seven, completing from a fourth to a third of a turn around the oogonium, equatorial angle 30° to 35°. The ridges are broad at the base, narrowing slightly near the summit, each with a broad, shallow median groove. Intercellular furrows wide and deep. Coronula cells seven, deeply concave on outer surface, corresponding in position with the cellular ridges and forming a suberect parapet-like ring around the summit orifice, the inner surface of the coronula ring constituting a broad funnel to the opening. Oospore membrane unknown.

Occurrence.—Sylamore (Basal Mississippian); Williamsburg, Missouri.

Holotype.—Catalog number 31003–2,

University of Missouri. *Paratypes.*—Catalog number 31003–3, University of Missouri.

Only twelve specimens of this species have been discovered, but within this number almost all degrees of calcification are represented. The single specimen with cellular ridges, the holotype, has one cellular ridge with a deep median groove. This may have been caused by incomplete calcification or by the subsequent loss of the last layers of deposit within the cell.

T. septemcostatus may be distinguished from other coronulate Sylamore trochiliscids by the number of spiral ridges.

Trochiliscus meeki Peck, n. sp.
Plate 10, figures 7–10

Oogonium coronulate, subspherical, of medium size, averaging from 0.7 mm. to 0.8 mm. in height, width equal to or slightly greater than height, greatest transverse diameter at or just below mid-height. Base truncate or gently rounded, summit deeply truncate. Ridges intercellular, ten, completing between a fourth to a half turn around the oogonium, equatorial angle 30° to 35°. The ridges are of uniform width from base to summit, narrow, each with a slight median groove. Cellular furrows deep and narrow. Coronula cells ten, deeply concave on outer surface, corresponding in position with the cellular furrows and forming an erect to sub-erect parapet-like ring around the summit orifice, the inner surface of the coronula ring constituting a narrow funnel to the opening. Oospore membrane unknown.

Occurrence.—*Devonocidaris jacksoni* zonule, Cerro Gordo member, Hackberry stage (Devonian); Bird's Hill, southwest of Rockford, Iowa.

Holotype.—Catalog number 698, University of Iowa. *Paratypes.*—Catalog number 699, University of Iowa.

This species is based on twelve specimens in the University of Iowa Collection. It closely resembles *Trochiliscus bilineatus* Peck and *Trochiliscus liratus* Peck, from the same locality and horizon, in size, shape, and degree of calcification, and can be recognized with certainty only by the number of spiral ridges. The ridges describe a smaller part of a complete turn around the oogonium in *T. meeki* than either of the above men-

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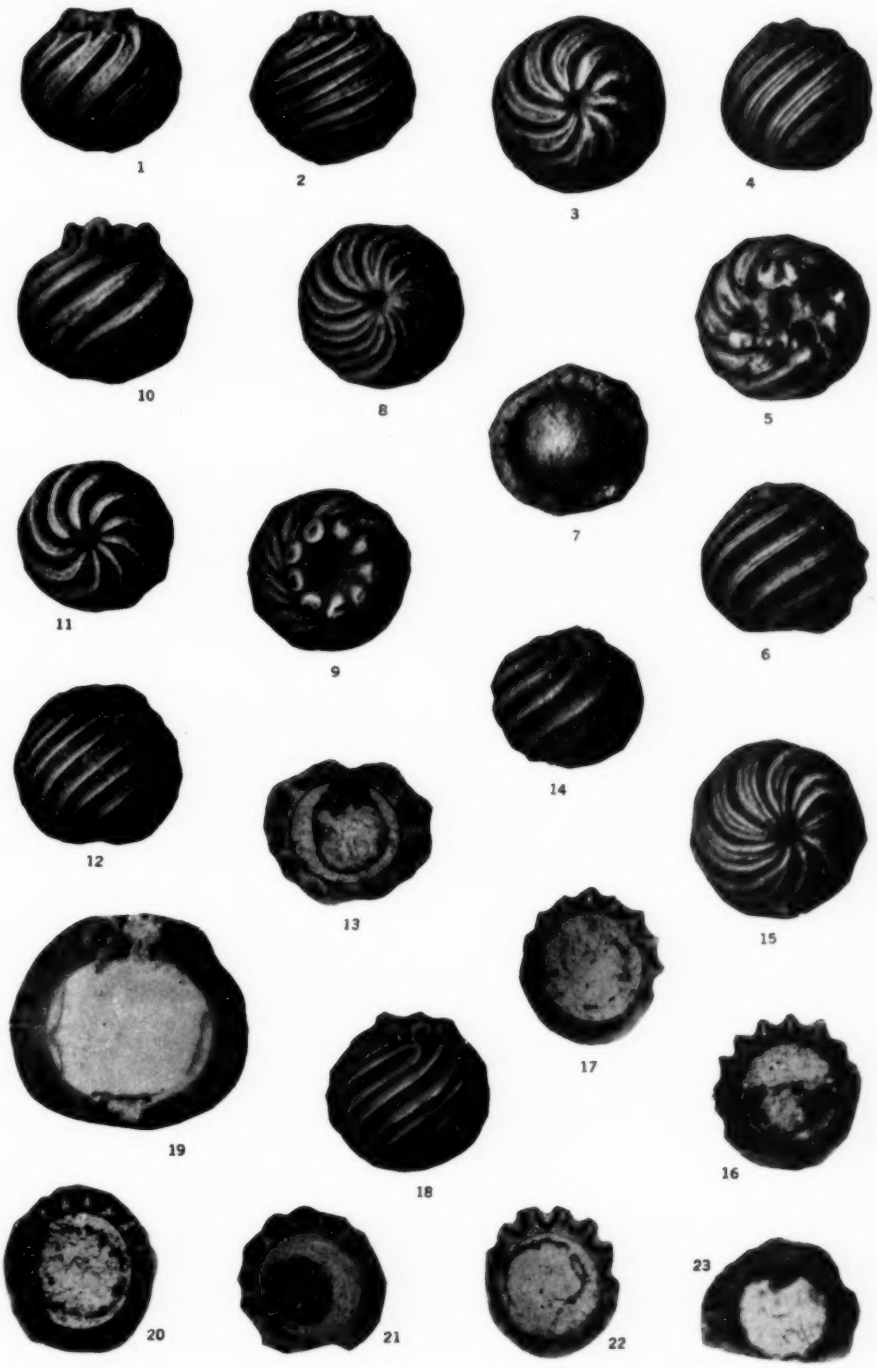
Explanation of Plate 11

All specimens enlarged twenty diameters

Figs. 1–23—*Trochiliscus laticostatus* Peck, n. sp. 1–7, Paratypes; 1, lateral view of paratype with wide intercellular zone dividing lateral edges of last deposit of calcium carbonate; 2, lateral view of specimen with lateral edges of the last deposit of calcium carbonate built up slightly above intercellular ridges; 3, basal view of large specimen with cellular ridges; 4, lateral view of specimen with comparatively narrow coalesced zone; 5, summit view of specimen with part of the coronula cells missing; 6, lateral view of specimen with sharp intercellular ridges; 7, broken specimen showing oospore. 8, 10, Holotype, basal and lateral views. 9, 11–23, Paratypes; 9, summit view of cellular ridged specimen with well developed coronula cells; 11, basal view of specimen with narrow intercellular ridges; 12, lateral view of specimen in which the cellular deposit has built up above the intercellular ridges and the specimen has eighteen ridges but only nine cellular units; 13, section, slightly oblique, showing the oospore membrane; 14, small specimen with sharp inter-cellular ridges; 15, basal view of specimen with cellular ridges; 16, 17, sections of specimens with sharp intercellular ridges—crossing the ridges at right angles; 18, lateral view of a specimen with well developed coronula cells, deep cellular furrows, and wide intercellular ridges with median grooves; 19, section showing the two polar openings and the coronula enveloping cell suture (enlarged about 30 diameters); 20, 21, sections crossing the spirals at right angles—cellular ridged specimens; 22, section crossing spirals at right angles—a specimen with cellular furrows; 23, section showing oospore membrane adjoining the inner wall of the oogonium. (p. 109)



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tioned species, but this character is too variable to be used in certain identifications.

T. decacostatus from the Sylamore of Missouri, another ten spiral form, is larger, has broader ridges, and a more deeply truncate base than *T. meeki*.

This species is named in honor of F. B. Meek, who was the first to record the occurrence of trochiliscids in North America and who first recognized their affinities with the Charophyta.

TROCHILISCUS BILINEATUS Peck, n. sp.
Plate 10, figures 25–30

Oogonium coronulate, subspherical, of medium size, ranging from 0.6 mm. to 0.8 mm. in height, width equal to height, greatest transverse diameter at or slightly below mid-height. Base and summit horizontally truncate, summit much more deeply than base. Ridges intercellular, nine, completing approximately a half turn around the oogonium, equatorial angle 25° to 30°. The ridges are of uniform width from base to summit, comparatively broad, each with a slight median groove. Cellular furrows narrow and deep. Coronula cells nine, deeply concave on outer surface, corresponding in position with the cellular furrows and forming an erect to sub-erect parapet-like ring around the large summit orifice, the inner surface of the coronula ring constituting a narrow funnel to the opening. Oospore membrane in some specimens greatly contracted.

Occurrence.—Devonocidaris jacksoni zonule, Cerro Gordo member, Hackberry Stage (Devonian) Bird's Hill, southwest of Rockford, Iowa; Snyder Creek shale, Ham's Prairie, Callaway County, Missouri; Columbus limestone, Marblehead Quarry, Sandusky, Ohio.

Holotype.—Catalog number 696, University of Iowa. *Paratypes.*—Catalog number 697, University of Iowa.

T. bilineatus is the most abundant trochiliscid species collected from the Devonian of Iowa. The specimens are exceptionally well preserved calcified forms, only a few being distorted. They show relatively little variation in size and shape, and evidently the enveloping cells had not acquired the ability of becoming completely calcified, as not a single specimen with cellular ridges was observed.

A collection of trochiliscids from the Columbia limestone at Marblehead, Ohio, has yielded two specimens on which the summit is not preserved. They agree in other details with the Iowa specimens, but in the absence of this highly important character, identification cannot be certain.

A large number of greatly distorted specimens from the Snyder Creek shale of Callaway County, Missouri, has been referred to this species. They are slightly smaller than the Iowa forms.

T. bilineatus corresponds very closely to one stage of calcification of *T. laticostatus* Peck from the Sylamore of Missouri. *T. bilineatus* is smaller, the spiral ridges have a lesser equatorial angle, and the ridges complete about one-half a turn about the oogonium. *T. herbertae* Peck from the Bell shale of Michigan is smaller, has cellular ridges, a greater equatorial angle, and the ridges complete only about one-third of a complete turn around the oogonium.

TROCHILISCUS LIRATUS Peck, n. sp.
Plate 10, figures 1–6

Oogonium coronulate, spherical to elongate spherical, of medium size, ranging in height from 0.7 mm. to 0.8 mm., higher than wide or with height and width subequal, greatest transverse diameter at or just below mid-height. Base broadly rounding, summit horizontally truncate. Ridges intercellular, eight, completing a half turn around the oogonium, equatorial angle 25° to 30°. The ridges are narrow, flat, of uniform width from base to summit, usually each with a small median groove. Cellular furrows wide and deep. Coronula cells eight, concave on the outer surface, corresponding in position to the cellular furrows and forming an erect parapet-like ring around the summit orifice, the inner surface of

the coronula ring constituting a narrow funnel to the opening. Oospore membrane unknown.

Occurrence.—Devonocidaris jacksoni zonule, Cerro Gordo member, Hackberry stage (Devonian); Bird's Hill, southwest of Rockford, Iowa; Columbus limestone, Marblehead Quarry, Sandusky, Ohio.

Holotype.—Catalog number 694, University of Iowa. *Paratypes.*—Catalog number 695, University of Iowa.

This species ranks third in abundance among the Iowa Devonian trochiliscids and is represented by relatively few specimens. The only other eight spiraled coronulate species recorded in North America is *T. octocostatus* Peck from the Sylamore of Missouri. *T. octocostatus* is larger, is typically cellular ridged, and the ridges make only about a fourth turn around the oogonium.

One partially preserved specimen from the Columbus limestone at Marblehead, Ohio, has been referred to this species. The Ohio form is slightly larger than the typical Iowa specimens.

Trochiliscus raricostatus, Peck, n. sp.
Plate 12, figures 22–24

Oogonium coronulate, elongate spherical, of medium size, about 0.8 mm. in height, width less than height, greatest transverse diameter at or just below mid-height. Base gently rounded, summit truncate. Ridges intercellular, seven, completing about a fourth turn around the oogonium, equatorial angle about 40°. The ridges are comparatively narrow, of uniform width from base to summit, each with a shallow median groove. Cellular furrows deep. Coronula cells seven, deeply concave on outer surface, corresponding in position with the cellular furrows and forming an erect parapet-like ring around the summit orifice, the inner surface of the coronula ring constituting a narrow funnel to the opening. Oospore membrane unknown.

Occurrence.—Devonocidaris jacksoni zonule, Cerro Gordo member, Hackberry stage (Devonian); Bird's Hill, southwest of Rockford, Iowa.

Cotypes.—Catalog number 693, University of Iowa.

This species is represented in the University of Iowa Collection by only two specimens, both somewhat distorted by pressure. They are distinct from other Iowa species in possessing only seven spiral ridges and from *T. septemcostatus* Peck, the only other described seven-spiraled form, in shape and size. The specimens described later herein as *Trochiliscus* sp. differ markedly in the form of the spiral ridges.

Although the shape of the cotypes is characteristic in being longer than wide,

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Explanation of Plate 12

All specimens enlarged twenty diameters

Figs. 1–3—Internal molds of trochiliscids from the Sylamore of Missouri.
4–9—*Trochiliscus decacostatus* Peck, n. sp. 4, 5, Lateral and summit views of specimen with intercellular ridges. The coronula cells have been lost and the pits indicate their former presence. 6–8, Lateral, basal, and summit views of specimen with wide intercellular ridges. 9, Basal view of specimen showing abnormal development of two adjoining ridges. (p. 109)
10–13—*Trochiliscus herbertae* Peck, n. sp. 10, Section crossing spirals at right angles; 11, Lateral view of a cellular ridged specimen; 12, Lateral view of a specimen with intercellular ridges; 13, Showing large summit orifice. (p. 115)
14–21—*Trochiliscus devonicus* (Wieland). 15, 21, Summit and basal views of specimens from the Snyder Creek of Missouri. 16–20, Lateral views of plesiotypes from the Onondaga at the Falls of the Ohio. 20, Lateral view showing the "inner chamber," the oospore. (p. 108)
22–24—*Trochiliscus raricostatus* Peck, n. sp. Cotypes, 22, lateral view; 23, 24, basal and summit views. (p. 114)
25–30—*Trochiliscus septemcostatus* Peck, n. sp. 25–26, 28, 30, Lateral and basal views of paratypes. 27, 29, Lateral and summit views of holotype. (p. 111)

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it is doubtful if this distinction could be made if a larger number of specimens were available, as the shape is a somewhat variable character in most other species and probably is in *T. raricostatus*.

TROCHILISCUS RUGULATUS Peck, n. sp.
Plate 13, figures 1–4

Oogonium noncoronulate, subspherical, of medium size, ranging in height from 0.6 mm. to 0.8 mm., width equal to height, greatest transverse diameter at mid-height. Base and summit very slightly truncate. Ridges intercellular, eight, completing approximately a half turn around the oogonium, recurving to an almost radial position near the summit, equatorial angle about 30°. The ridges are sharp and narrow, separated by wide, shallow cellular furrows. Summit orifice surrounded by a low ridge connecting apical ends of spirals. Oospore membrane unknown.

Occurrence.—Devonocidaris jacksoni zonule, Cerro Gordo member, Hackberry stage (Devonian); Bird's Hill, southwest of Rockford, Iowa.

Holotype.—Catalog number 691, University of Iowa. *Paratypes.*—Catalog number 692, University of Iowa.

This form ranks second in abundance and is the most easily recognized of Iowa Devonian trochiliscid species. The most outstanding character, aside from the number of sharp spiral ridges, is the very wide, shallow cellular furrows. The wide furrows and number of spiral ridges make it easily differentiated from *T. devonicus* Wieland and *T. bellatulus* Peck, the only other noncoronulate species recorded from North America.

T. bulbiformis Karpinsky, from the Devonian of Russia, resembles *T. regulatus* in the number of spiral ridges and in external appearance. The Russian species is much smaller, ranging from 0.2 mm. to 0.4 mm. in height.

TROCHILISCUS BELLATULUS Peck, n. sp.
Plate 10, figures 21, 23, 24

Oogonium noncoronulate, subspherical, medium large, height of the holotype 1 mm., width equal to height, greatest transverse diameter slightly above mid-height. Summit slightly truncate, base rounded. Ridges intercellular, ten, completing approximately a half turn around the oogonium, recurving to an almost radial position near the base and summit, equatorial angle about 25°. The ridges are sharp and narrow, separated by wide, shallow cellular furrows. Summit orifice surrounded by a low ridge connecting ends of the spiral ridges. Oospore membrane unknown.

Occurrence. — Columbus limestone, Marblehead Quarry, Sandusky, Ohio.

Holotype.—Catalog number 31005–4, University of Missouri.

The description is based on a single specimen taken from a small piece of cherty limestone loaned by E. M. Kindle of the Canadian Geological Survey. The most outstanding character of *T. bellatulus* is the ten sharp ridges, a feature that clearly differentiates it from all other noncoronulate Trochiliscaceae with the exception of *T. lemoni* Knowlton. I have not had an opportunity of examining *T. lemoni*, but Knowlton's figures and description indicate that it is much larger than *T. bellatulus*, and that the ridges are broad and rounded.

TROCHILISCUS HERBERTAE Peck, n. sp.
Plate 12, figures 10–13

Oogonium coronulate, subspherical, small, ranging from 0.5 mm. to 0.8 mm. in height, slightly higher than wide or with subequal diameters, greatest transverse diameter about mid-height. Base and summit horizontally truncate, summit more deeply than base. Ridges cellular, nine, completing about a fourth turn around the oogonium, equatorial angle 30° to 35°. The ridges are of uniform width from base to summit, comparatively broad, very convex, but occasionally each has a shallow, narrow median groove. Intercellular furrows narrow and deep. Coronula cells nine, deeply concave on outer surface, corresponding in position with the cellular ridges and forming an erect to sub-erect parapet-

like ring around the large summit orifice, the inner surface of the coronula ring constituting a broad funnel to the opening. Nature of the oospore membrane unknown.

Occurrence.—Bell shale (Devonian) pocket in the Dundee limestone, Calcite Quarry, Rogers City, Michigan.

Cotypes.—Catalog number 31003–4, University of Missouri.

This species is based on about fifty specimens from the Bell shale of Michigan, all somewhat distorted by pressure. It is one of the smallest species noted in North America and with the possible exception of *T. lemoni* (Knowlton), a species that I have not seen, the only Devonian occurrence in which the ridges are cellular. Approximately one-third of the specimens reached the stage of complete calcification, the others grading through varying stages to sharp intercellular ridges and cellular furrows.

Typical specimens of this species may be easily distinguished by their small size, cellular ridges, and comparatively large summit orifice.

This species is named in honor of Herberta L. Van Pelt, Providence, Rhode Island, who kindly made her collection of Bell shale trochiliscids available to me for study.

TROCHILISCUS sp.
Plate 13, figures 8–11

In the Sylamore of Missouri and Devonian of Iowa there have been found five specimens of trochiliscids whose relationships are not clear. They are spherical, small, about 0.6 mm. in height with a slightly greater width, and seemingly noncoronulate. The base is rather deeply truncate and the summit gently rounded or drawn out almost to a point. The ridges are narrow, sharp and prominent near the base, widening rapidly and becoming lower and concave as they ascend. Near the summit they are low and broad with a wide shallow median furrow. This furrow may end in a circular concavity or may narrow and grade into a sharp ridge at the apex.

These specimens may represent internal molds but I know of no trochiliscid that would yield a body of this appearance on the loss of the oogonium wall.

Family SYCIDIACEAE[6] Karpinsky

Genus SYCIDIUM G. Sandberger

More or less spherical oogonia with outer shell composed of a variable number of meridional units—probably never more than twenty, commonly sixteen or

[6] Written "Sycididae" by Karpinsky.

EXPLANATION OF PLATE 13

All specimens enlarged twenty diameters unless otherwise stated.

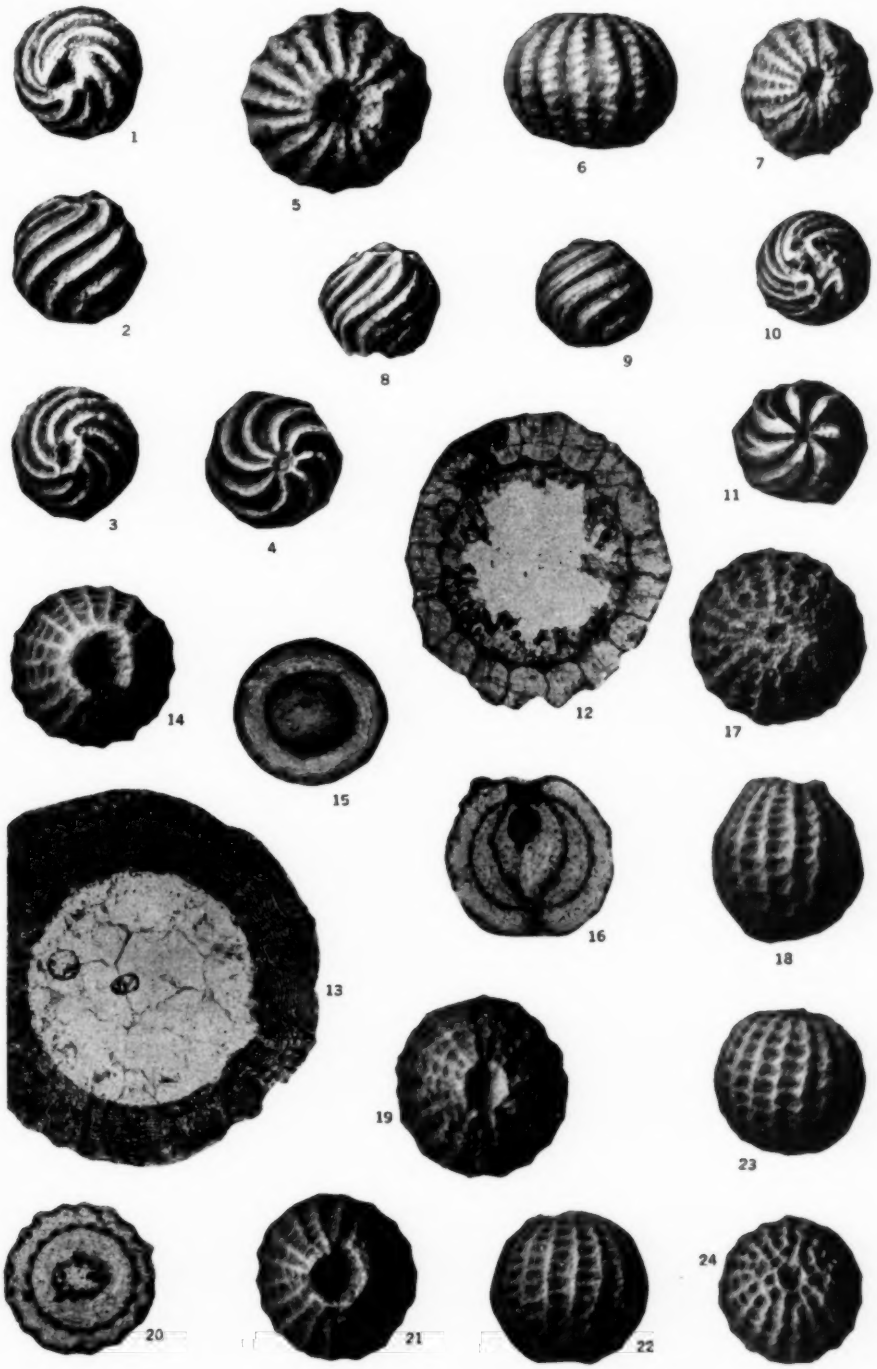
FIGS. 1–4—*Trochiliscus rugulatus* Peck, n. sp. 1, 2, 4, Summit, lateral, and basal views of holotype. 3, Summit view of paratype. (p. 115)

5–7—*Sycidium clathratum* Peck, n. sp. 5, 6, Summit and lateral view of a normal sized specimen. 7, Summit of a small specimen. (p. 117)

8–11—*Trochiliscus* sp. 8, Lateral view of specimen from the Sylamore. 9–11, Lateral and summit view of one specimen and basal of another from Devonian of Iowa. (p. 116)

12, 13—*Sycidium* sp. (After Karpinsky—enlarged). 12, Section showing divisions between cells. 13, Section showing laminae of organic material.

14–24—*Sycidium foveatum*, n. sp. 14, Summit view showing wide funnel-shaped summit opening. 15, Specimen with base ground off to show position of oospore. 16, Longitudinal section showing thickness of wall, both openings, and oospore membrane. 17, Basal view showing normal preservation. 18, Lateral view. 19, Summit view of specimen with small summit opening. 20, Cross-section at the equator. 21, 22, Summit and lateral views of normal specimen. Note lateral alignment and alternating arrangement of pits in adjoining rows. 23, 24, Lateral and basal views of well-preserved specimen. Note the arrangement of pits around the basal opening. (p. 117)



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eighteen—expressed on the outer surface as vertical grooves or ridges; each subdivided transversely so as to consist of a columnar series of pits or elevations varying in number from less than eleven to more than eighteen; units of adjacent columns in lateral alignment or alternating position. Oogonium with a small basal and somewhat larger summit opening. Oospore membrane of mature oogonia usually contracted.

The genus *Sycidium* was first defined by G. Sandberger (38, 39) in 1849 from specimens discovered in the Devonian of Eifel. His illustrations are reproduced in Plate 9, figures 1*a–d*. *Sycidium reticulatum* G. Sandberger, the only species described in the article including the generic description, is herein designated the genotype.

Sandberger considered *Sycidium* a polyp genus, most closely related to Goldfuss' genus *Conodictyum*. Since that time these forms have been classified with a variety of groups both animal and vegetable, but have generally been considered as problematic. As pointed out in the discussion on the morphology of the Sycidiaceae they are logically to be classified along with the Trochiliscaeae as a charophyte group.

SYCIDIUM FOVEATUM Peck, n. sp.
Plate 13, figures 14–24

Oogonium spherical to elongate spherical, large, averaging about 1.0 mm. in height, greatest transverse diameter at or just below mid-height, equal to or slightly less than height. Base gently rounded to slightly truncate, summit truncate. Grouped around a small, somewhat depressed basal opening are nine shallow pits that branch into eighteen meridional rows of about twelve pits extending from the point of origin to the comparatively large, funnel-shaped summit opening. Pits in adjoining rows hexagonal in shape and alternating or rectangular and in lateral alignment, commonly both arrangements evident on a single specimen. Oospore membrane contracted, usually extending as an elongate spheroid from summit opening to basal opening, sometimes folded, occasionally in contact with oogonium wall.

Occurrence.—Sylamore (Basal Mississippian); Williamsburg, and Providence, Missouri.

Cotypes.—Catalog number 31004–2, University of Missouri.

This species is unusual in that the eighteen rows of meridional pits originate from nine pits grouped about the basal opening. The only other species so far noted in North America, *Sycidium clathratum* Peck, has only sixteen rows of meridional pits and they extend as unbroken units from the basal opening to the summit opening, as is the case with the European forms described by Karpinsky. Also, *S. clathratum* and the European Sycidiaceae have a regular arrangement of the pits, in lateral alignment in adjoining rows or alternating. This has been found to be an inconstant character in *S. foveatum*. The alternating disposition is the more prevalent but both arrangements occur on almost every individual.

S. foveatum is exceptionally abundant in the Williamsburg locality of the Sylamore and one specimen was collected at Providence, Missouri. Almost every Sylamore locality yields small smooth spherical bodies with a small indentation at one end and a short projection at the other (Pl. 12, figs. 1–3). Most of these are interpreted as worn specimens or as internal molds of Sycidiaceae. Sections of these bodies often show the characteristic elongate spherical oospore membrane of *S. foveatum*. However, a few are definitely internal molds of Trochiliscaceae.

SYCIDIUM CLATHRATUM Peck, n. sp.
Plate 13, figures 5–7

Oogonium depressed spherical, large, averaging about 0.9 mm. in height, wider than high, greatest transverse diameter at mid-height averaging about 1.2 mm. Base and summit deeply truncate. Extending from the small basal opening to the slightly larger summit opening are sixteen meridional ridges separated by

wide shallow furrows. Equally spaced on the ridges and in lateral alignment are fifteen or sixteen small tubercles. The tubercles are connected laterally by faint lines dividing the furrows into fifteen or sixteen shallow rectangular pits. Oospore unknown.

Occurrence.—Sylamore (Basal Mississippian); Williamsburg, Missouri.

Cotypes.—Catalog number 31004–1, University of Missouri.

The number of meridional ridges and the depressed spherical shape makes this species easily differentiated from *S. foveatum* Peck, the only other known North American species. *S. clathratum* resembles *S. volbrothi* Karpinsky from the Devonian of Russia in shape and in lacking the funnel-shaped summit opening. *S. volbrothi* is much smaller and has eighteen meridional ridges.

BIBLIOGRAPHY

With the exception of a few references on the modern types of Charophyta that have been found particularly useful this bibliography is concerned entirely with trochiliscids. It is essentially a reproduction of Karpinsky's trochiliscid bibliography with the addition of more recent publications. In so far as I am able to determine it is complete with the exception of a few textbook references that add nothing to the knowledge of trochiliscids. Complete bibliographies on post-Mississippian Charophyta are published in (11) and (27). Italic numbers are trochiliscid references.

1. Bell, W. A., A new genus of Characeae and new Merostomata from the Coal Measures of Nova Scotia: *Roy. Soc. Canada, Proc. and Trans.*, 3d. ser., vol. 16, pp. 159–168, 1922.

2. Bock, J., Geogn. Beschr. d. untersil. u. dev. S. d. Gouv. St. Petersb.: *Mater. z. Geologie Russlands*, 1, 1869.

3. Braun, A., Characeen: *Cohn's Kryptogamen-Flora and Schlesien*, Band 1, 1876.

4. Choubert, B., Sur l'Existence d'Algues Dévoniennes dans le Niveau de "Calcaire Rose" du Système du Kunderlungu du Katanga: *Classe des Sciences de l'Acad. Roy. de Belgique, Bull.*, 5th ser., vol. 18, pp. 1421–1431, 1932.

5. Choubert, B., Nouvelles Recherches sur les Algues du Niveau du "Calcaire Rose Oolithique" du Kundelungu Supérieur du Congo Belge (Province Orientale et Katanga): *Société Belge de Géologie, Bull.*, vol. 42, pp. 63–70, 1932.

6. Dana, J., Manual of Geology, p. 582, 1895.

7. Dawson, J. W., Saccammina? (Calcisphaera) eriana (an Erian Rhizopod of uncertain affinities): *Canadian Naturalist and Quart. Jour. Sci.*, new ser., (no. 10) pp. 5–8, 1883.

8. Dawson, J. W., Saccammina eriana: *Am. Jour. Sci.*, 3d ser., vol. 37, p. 318, 1889.

9. Deecke, W., Ueber einige neue Siphoneen: *Neues Jahrb. fur Mineralogie, Geologie und Palaeontologie*, Band 1, pp. 1–8, 1883.

10. Ehrenberg, Ueber fortschreitende massenhafter mikroskopische Lebensformen in den untersten silurischen Thonschichten bei Petersburg: *Monatsberichte d. K. Preuss. Akad. d. Wissenschaften zu Berlin*, pp. 295–311, 1858.

11. Ehrenberg, Über die Obersilurischen und Devonischen Mikroskopischen Pteropoden Polythalamien und Crinoiden bei Petersburg in Russland: *Monatsberichte d. K. Preuss. Akad. d. Wissenschaften zu Berlin*, pp. 599–601, 1862.

12. Groves, James, A curious fossil Charophyte fruit: *Geol. Mag.*, vol. 57, pp. 126–127, 1920.

13. Groves, James, and Bullock-Webster, George R., The British Charophyta: *Ray Soc., London*, vol. 1, 1920.

14. Groves, James, and Bullock-Webster, George R., A sketch of the geological history of the Charophyta: The British Charophyta, *Ray Soc., London*, vol. 2, pp. 72–88, 1924.

15. Groves, James, Fossil charophyte-fruits from Texas: *Am. Jour. Sci.*, 5th ser., vol. 10, pp. 12–14, 1925.

16. Karpinsky, A., Die Trochilisken: *Mémoires du Comité Géologique*, Nouvelle série Livraison 27, 1906. (Russian and German.)

17. Karpinsky, A., Letter from Karpinsky to the International Congress in Mexico in 1906: *Comptes rendus du Congres International, Mexico*, vol. 10, pp. 122–124, 1906.

18. Kidston, R., and Lang, W. H., On Old Sandstone plants showing structure, from the Rhynie chert beds, Aberdeenshire: *Roy. Soc. Edinburgh, Trans.*, vol. 52, pp. 876–881, 1921.

19. Knowlton, F. H., Description of a problematic organism from the Devonian at the Falls of the Ohio: *Am. Jour. Sci.*, 3d ser., vol. 37, pp. 202–209, 1889.

20. Lagorio, Alexander, Microscopische Analyse Ostbaltischer Gebirgsarten, Dorpat, pp. 36–42, 1876.

21. Meek, F. B., Descriptions of new species of invertebrate fossils from the Carboniferous and Devonian rocks of Ohio: *Acad. Nat. Sci., Philadelphia, Proc.*, pp. 83–84, 1871.

22. Meek, F. B., *Geol. Survey. of Ohio*, vol. 1, p. 219, 1873.
23. Migula, W., Die Characeen Deutschlands, Oesterreichs und der Schweiz: *Rabenkorst's Kryptogamen-Flora v. Deutschl. Oesterr. u. Schweiz, zweite Auflage*, Band 5, 1897.
24. Miller, S., North American Geology and Paleontology, p. 155, 1889.
25. Oltmanns, F., Morphologie und Biologie der Algen, *zweite Auflage*, Band 1, 1922.
26. Pander, Christian H., Monographie der fossilen Fische des Silurischen Systems des russischbaltischen Gouv., p. 17, 1856.
27. Pander, Christian H., Ueber die Placodermen des Devonischen Systems, p. 13, St. Petersburg, 1857.
28. Pia, Julius, Die Siphoneae verticillatae vom Karbon bis zur Kreide: *Abhandlungen d. Zool.-Botan. Gesellschaft*, Heft 2, p. 227, Wien, 1920.
29. Pia, Julius, Pflanzen als Gesteinsbilder, pp. 133–143, 1926.
30. Pia, Julius, Hirmer's Handbuch der Paälobotanik, Band 1, pp. 88–92, 1927.
31. Pia, Julius, Einige allgemeine an die Algen des Paläozoikums anknüpfende Fragen: *Paltont. Zeitschr.*, Band 13, p. 17, 1930.
32. Potonie, H., Die Silur- und die Culm-Flora des Harzes u. d. Magdeburischen: *Abhandl. d. k. Preuss geolog. Landesanst.* N. Folge, H. 36, p. 25, 1901.
33. Quenstedt, Fr. Aug., Epochen der Natur, p. 344, 1861.
34. Quenstedt, Fr. Aug., Handbuch der Petrefaktenkunde, 2 Aufl., p. 843, 1867.
35. Quenstedt, Fr. Aug., Handbuch der Petrefaktenkunde, 3 Aufl., p. 1083, 1885.
36. Reid, Clement, and Groves, James. The Charophyta of the lower Headon beds of Hordle Cliffs: *Geol. Soc. London, Quart. Jour.*, vol. 77, pp. 175–192, 1921.
37. Sandberger, F., Sycidium aus dem Devon am Sjass: *Neues Jahrb. f. Mineralogie, Geologie und Palaeontologie*, Band 2, pp. 199–200, 1880.
38. Sandberger, G., Eine neue Polypengattung Sycidium aus der Eifel: *Neues Jahrb. f. Mineralogie, Geognosie, Geologiem, und Petrefaktenkunde*, pp. 671–672, 1849.
39. Sandberger, G., Sycidium, Feigenpolyp, eine neue Gattung aus d. Eifel: *Verhandl. d. Naturhist. Ver. d. preuss. Rheinl. u. Vestphal. Sechster Jahrg. Bonn.*, pp. 264–265, 1849.
40. Seward, A. C., Catalogue of the Mesozoic plants of the British Museum, pt. 1, pp. 9–14, 1894.
41. Seward, A. C., Fossil plants: *Cambridge Biol. Ser.*, vol. 1, pp. 222–228, 1898.
42. Steinmann, Gustav, Einfuhrung in die Paläontologie, *zweite Auflage*, pp. 22–23, 1907.
43. Thomas, A. O., Small fossils from the Lime Creek shales: (Abstract) *Geol. Soc. America, Bull.*, vol. 32, pp. 130–131, 1921.
44. Trautschold, H., Ueber Dendrodus und Cocosteus: *Verhandlungen der Russisch-Kaiserlichnen Mineralogischen Gesellschaft zu St. Petersburg*, Band 15, 152–153, 1880.
45. Ulrich, E. O., Contributions to American Palaeontology, vol. 1, (no. 1), p. 34, Cincinnati, 1886.
46. Ulrich, E. O., *Geol. Mag.*, p. 375, 1886.
47. Wieland, G. R., Further notes on Ozarkian seaweeds and oolites: *Am. Mus. Nat. Hist.*, vol. 33, pp. 245–246, 1914.
48. Williamson, W. C., On the organization of the fossil plants of the Coal-Measures: *Royal Society, Philos. Trans.*, vol. 171, Pt. 2, pp. 520–525, London, 1880.

The following papers have appeared since the completion of the manuscript.

49. Groves, James, Charophyta: Fossilium Catalogus, II, Plantae, Part 19, 1933.
50. Hacquaert, Armand L., Notes sur les Genres Sycidium et Trochiliscus: *Musée royal d'Histoire Naturelle de Belgique. Bull.*, vol. 8, 1932.
51. Hacquaert, Armand L., Recherches sur quelques Roches Carbonatées à grain fin et sur des Calcaires oolithiques du Katanga: *Ann. du Service des Mines*, vol. 3, Brussels, 1933.

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OSTRACODES FROM THE UPPER PENNSYLVANIAN AND THE LOWER PERMIAN STRATA OF KANSAS: II. THE GENUS BAIRDIA

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ABSTRACT

The genus *Bairdia* is defined; and the hinge and marginal structures, the muscle scar, and the structure of the shell wall are discussed in detail. The plan of orientation used in this paper is explained. Morphological criteria of specific value are indicated, as well as morphological features which are often of no specific value but are merely individual variations or variations which are due to age. Twenty-three species of *Bairdia* from Kansas of Late Pennsylvanian and of Early Permian age, fourteen of which are new, are described, figured, and their observed ranges given. One species of *Bairdia* from Oklahoma is figured, assigned by Warthin to *Bairdia altifrons* Knight.

This paper is the second of a series of three describing the ostracode fauna of the Upper Pennsylvanian and the Permian strata of Kansas. The reader is referred to the first paper[1] for acknowledgments, register of fossil localities, an explanation of methods, a consideration of variation within species, and a list of the several museums where types are deposited.

The species of the genus *Bairdia* are very difficult to differentiate because of their simplicity. Hence in the literature dealing with American Pennsylvanian forms many species have been confused while many names are synonyms. This is due in part to the difficulties inherent in dealing with species of *Bairdia*, as mentioned above, but also in large part to the rapidity with which that literature has been appearing in the last few years and in many cases to the inadequacy of the original figures and descriptions of the species. Fully aware of these difficulties every effort has been made to examine authentic specimens of all species obtainable and wherever possible the types themselves have been carefully studied. Especial care has been employed in arranging synonymies.

I must not fail to express my gratitude to Dr. Ray S. Bassler, Dr. Raymond C. Moore, Dr. H. N. Coryell, Dr. G. E. Condra, and Mr. M. E. Upson for facilitating the examination of type specimens without which little progress could have been made. Doctor Bassler has also helped clarify one of the most difficult questions in identification.

[1] Kellett, Betty, Ostracodes of the Upper Pennsylvanian and the Lower Permian strata of Kansas, I. The Aparchitidae, Beyrichiidae, Glyptopleuridae, Kloedenellidae, Kirkbyidae, and Youngiellidae: *Jour. Paleontology*, vol. 7, pp. 59–108, pls. 13–16, March, 1933.

SYSTEMATIC DESCRIPTIONS

Family BAIRDIIDAE G. O. Sars, 1887

Genus BAIRDIA M'Coy, 1844

Bairdia M'COY, *1844*, Synopsis Char. Carb. Fossils Ireland, p. 164.

Shell subtriangular or rhomboidal, with the greatest height near the middle, inequivalved. . . . rounded anteriorly and more or less acuminate posteriorly, generally smooth; dorsal margin more or less strongly convex.[2]

The left valve is conspicuously larger than the right and apparently overlaps it, although the overlap is in reality slight and discontinuous. A more or less prominent sinuosity or lip protrudes upward along the ventral margin of the left valve just anterior to the center (see Pl. 14, figs. 1*a*, 1*h*, 4; Pl. 15, figs. 3*b*, 5*a;* Pl. 17, fig. 5*b;* and Pl. 19, fig. 6*b*), with a corresponding indentation in the right valve (see Pl. 17, fig. 5*c*). The hinge structure of the Carboniferous species examined consists typically of a groove along the dorsal margin of the larger left valve, the lower edge of which groove is ridgelike and fits into a groove on the right valve. The interior muscle scar is circular as is characteristic of the Bairdiidae.

Genotype by subsequent designation —*Bairdia curta* M'Coy. Mountain limestone, Mississippian, Ireland.

Hinge and marginal structures.—Since it is becoming increasingly evident that the hinge and marginal structures of Paleozoic ostracodes may be of considerable taxonomic importance, and since these characters in the genus *Bairdia* seem to have escaped notice in print, it seems proper to devote some space to describing such structures as found in some of the excellent material at hand, such as the unusually well preserved specimens from Loc. 60.

Typically the hingement in the genus *Bairdia* consits of a groove in the larger left valve into which fits the edge of the smaller right valve. On the right valve also there is a tendency to develop a groove into which fits the low, often indistinct ridge which forms the lower border of the groove on the left valve. Commonly the hingement is developed only along the straight portion of the dorsal margin, and it is often most distinct at the anterior end.

Among the various species studied there is considerable range in degree of development of the hinge and marginal structures. The groove in the larger left valve, which can best be seen by tilting the valve up slightly on the dorsum, is quite well developed in *B. beedei* Ulrich and Bassler. In *B. garrisonensis* Upson, *B. reussiana* Kirkby, and *B. seminalis* Knight the lower edge of this groove appears as a thin, sharp, downward extending ridge. The groove is usually most pronounced at its extremities beneath the dorsal angles; in some species the middle portion of the groove is quite narrow; and in others such as *B. florenaensis* Upson, only the terminal portions of the groove remain. These terminal grooves are joined by a narrow ridge apparently continuous with their lower edges. In *B. hoxbarensis* Harlton the dorsal groove is more elongate than noted in any other species, extending half way down the post-dorsal slope.

The groove on the dorsum of the right valve can best be seen when the valve is tilted up on its venter rather than lying flat. It can be seen clearly under a magnification of 43.2 diameters in the following species: *B. beedei, B. seminalis, B. garrisonensis, B. pompilioides* Harlton, *B. crassa* (?) Harlton, and *B. hooverae* Kellett, n. sp.

Ventrally a marginal groove is found on the left valve only where it is typically developed over and in front of the ventral lip as shown in the figure of *B. florenaensis* (Pl. 14, fig. 4). The degree of development varies: in *B. folgeri*, n. sp., and *B. florenaensis* it is strong; and in *B. beedei* and *B. hoxbarensis* it is weak. In *B. pompilioides* the groove is not developed

[2] Ulrich, E. O., and Bassler, R. S., *Maryland Geol. Survey*, Silurian, p. 319, 1923.

in front of the ventral lip but only above it. The most conspicuous ventral groove was observed in several well-preserved specimens of the thick shelled *B. seminalis* where it was deep and extended not only along the entire venter but around both ends to the hinge, being quite pronounced under the upper side of the anterior beak.

There may be a little actual overlap of the left valve over the right in the antero-dorsal portion as seen in specimens of *B. florenaensis*.

Muscle scar pattern.—The centrally situated muscle scar pattern on the inner surface of each valve is located in the thickest part of the carapace. The scar pattern is very slightly to very deeply impressed, as in *B. beedei*, circular or approximately so, and composed of a slightly raised central dot surrounded in an irregular manner by other more or less regularly shaped elevations (see Pl. 14, fig. 2). Figures of *B. ampla* (Reuss)[3] and of *B. hisingeri* (Münster)[4] show such scar patterns. The scar pattern of *B. chaseae*, n. sp., is composed of approximately ten slight elevations around a central one, and a specimen of *B. florenaensis* shows a slight antero-dorsal extension of the muscle scar composed of a row of two or three small elevations such as make up the scar itself.

Structure of the shell wall.—Although the structure of the shell wall of recent ostracodes was described some forty years ago,[5] it is only recently[6] that paleontologists have given such structures much thought. Briefly, the shell wall of the *Bairdia* is composed of two layers: an outer calcareous lamella, and an inner lamella the greater part of which is membraneous and is lost through decay in fossil specimens, only the peripheral calcareous portion bordering the free edges of the valve remaining. The inner edge of this calcified portion of the inner lamella is called the inner margin, and the outer edge of the shell the outer margin. The peripheral part of the calcified portion of the inner lamella is fused with the outer lamella, their line of fusion being called the line of concrescence. An open space is left between the two lamellae along the inner margin. Figure 5*c*, Plate 16, shows the inside of a valve with a narrow white band paralleling the free margins: the inner edge of this white band is the inner margin and the outer edge the line of concrescence. The dark marginal area is known as the marginal zone. It can be seen in this figure that ventrally the inner margin and the line of concrescence almost coincide, the area between them being prominent only antero-ventrally and posteriorly. This is characteristic of all of the Pennsylvanian and Permian specimens of *Bairdia* examined. The line of concrescence can be seen through the transparent valve of figure 5*b*, Plate 16.

Immature molts of *Bairdia* may perhaps lack the calacareous inner lamella. Immature molts of *B. seminalis* Knight from Loc. 60, where they are common and almost perfectly preserved, were very thin-shelled and apparently lacked the calcareous inner lamella.

The shell wall of *Bairdia* contains fine pores.

Orientation.—To facilitate specific differentiation in the *Bairdia* it is necessary that the specimens be similarly orientated in lateral view. But it is very difficult if not impossible to fix upon a consistent orientation applicable to all species of *Bairdia* because of the lack of a constantly occurring feature such as the straight hinge in many families, and because the position of most of the marginal features in *Bairdia* vary in relation to each other. Consequently no definite orientation has been hitherto adopted, the matter having been left largely to

[3] Richter, *Zeits. d. G. Ges.*, 19, pp. 216–36, pl. 5, fig. 27, 1867. Jones and Kirkby, *Quart. Jour., Geol. Soc. London*, vol. 35, pp. 565–80, pl. 28, fig. 23, 1879.

[4] *Idem.*, pp. 565–80, pl. 29, fig. 10.

[5] Müller, G. W., Die Flora und Fauna des Golfes von Neapel, Monogr. 21, Ostracoda, 1894.

[6] Alexander, C. I., *Jour. Paleontology*, vol. 7, pp. 179–184, pl. 25, June, 1933.

chance. The plan finally selected for use in this paper as being applicable to almost all species is that of orienting the more or less straight venter parallel to a horizontal line; a plan which is inapplicable to only two of the species herein described, both of which have long, very convex venters. These are *B. beedei* Ulrich and Bassler (Pl. 14, figs. 1*a–h*), and *B. marmorea*, n. sp. (Pl. 15, figs. 1*a–h*).

Morphologic criteria of specific value.—The above constant orientation brings out one of the most important criteria for use in specific differentiation; that is, the position of the anterior and posterior extremities in relation to the mid-height of the valve. Thus in the species shown in Plate 15, figures 3*a*–4*b*, the posterior beak is just below the mid-height of the valve, a fairly high position for the posterior beak; and the anterior beak is at the mid-height of the valve or slightly below, a quite low position for the anterior beak. In another species (Pl. 15, figs. 5*a–g*) the posterior beak is lower and the anterior is much higher. The anterior beak of another (Pl. 16, fig. 7*b*) is very high or near the dorsum, and in still another (Pl. 17, fig. 3) it is very low. The general shape in outline is, of course, of greatest importance, and in figuring new species of *Bairdia* at least two views should be given: the side and a dorsal or ventral view. The shape of the extremities and the amount and character of the dorsal overlap are also most helpful characters.

Variation within species.—A careful study of numerous collections of many individuals from many horizons and localities has shown that the differences described below as individual variations are to be found in any collection from a given horizon and locality containing a large number of individuals. In such a collection the intergradation between the extremes is complete and the characters here considered of specific value are constant throughout each series. The variation within a species of the length-height ratio may be considerable, for example in a collection of *B. beedei* from the same horizon and locality the length-height ratio varies from 1.76 (Pl. 14, fig. 1*c*) to 1.65 (Pl. 14, fig. 1*f*). This same variation has been noted within many other collections of *B. beedei* from both higher and much lower horizons. Furthermore the variation in length-height ratio may change the outline in side view considerably, the shorter individuals of a species often having steeper antero and post-dorsal slopes than the longer individuals of the same species. Both *B. seminalis* Knight (Pl. 15, figs. 2*b*, 2*c*) and *B. crassa* (?) Harlton (Pl. 15, figs. 5*b*, 5*d*) show this variation of the dorsal slopes within species.

A certain amount of difference between the mature and immature molts of species of *Bairdia* may be noted. This is usually expressed in the more pointed ends of the immature molts (see the ontogenetic series in Pl. 15, figs. 1*a–h*, Pl. 16, figs. 1*a–h* and Pl. 17, figs. 1*a–h*).

BAIRDIA BEEDEI Ulrich and Bassler
Plate 14, figures 1*a–h*, 2

Bairdia beedei ULRICH AND BASSLER, *1906*, U. S. Nat. Mus., Proc., vol. 30, p. 161, pl. 11, figs. 19, 20; Cottonwood shales, 2 miles east of Cottonwood Falls, Kansas.—*1923*, Maryland Geol. Survey, Silurian volume, p. 319, text fig. 3 (original figure redrawn).—WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 69, pl. 5, figs. 9*a*, *b*; Holdenville formation, Oklahoma.—UPSON, *1933*, Nebr. Geol. Survey, Bull. 8, 2d ser., p. 16, pl. 1, figs. 4*a–c;* Garrison shale formation, Permian, Kansas.

Bairdia beedei abrupta ULRICH AND BASSLER, *1906*, U. S. Nat. Mus., Proc., vol. 30, p. 161, pl. 11, figs. 21, 22; Cottonwood shales, Permian; 2 miles east of Cottonwood Falls, Kansas.

Bairdia hispida HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 140, pl. 21, fig. 14; Cisco formation; Eastland County, Texas.—*1929*, Texas Univ., Bull. 2901, p. 155, pl. 3, figs. 2*a*, *b;* Graham formation, Middle Pennsylvanian; Menard County, Texas.—DELO, *1930*, Jour. Paleontology, vol. 4, no. 2, p. 163, pl. 12, figs. 14*a*, *b;* deep well, Menard County, Texas.

Bairdia moorei KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 318, pl. 43, figs. 1*a–c;* Fort Scott limestone, lower Henrietta, Pennsylvanian; St. Louis, Missouri.—CORYELL AND OSORIO, *1932*, Am. Midland Nat., vol.

13, no. 2, p. 33; Nowata shale, Marmaton, Pennsylvanian; Tulsa County, Oklahoma. —CORYELL AND BILLINGS, *1932*, Idem., vol. 13, no. 4, p. 173, pl. 17, fig. 4.

Bairdia wrefordensis UPSON, *1933*, Nebr. Univ., Bull. 8, 2d ser., p. 22, pl. 2, figs. 5*a–b*; Fourmile limestone, Wreford formation, Permian; Kansas.

Carapace in lateral view subrhomboidal and rather elongate; ventral margin gently convex, rounding broadly into the extremities; dorsal margin slightly angled in the post-dorsal portion; anterior beak narrowly rounded and at the mid-height of the valve; posterior beak bluntly acuminate and very slightly below the mid-height; carapace moderately thick in ventral view with evenly tapered ends; right valve much more convex than the left;[7] greatest height central; greatest thickness in the central portion in a horizontal line along the mid-height of the valves with almost flat surfaces sloping on either side to the dorsal and ventral peripheries; dorsal apparent overlap conspicuous with a long straight hinge line about one-half the length of the carapace terminated at each end by an obtuse angle; valves meeting smoothly with slight indentation; antero-ventral sinuosity in the line of juncture of the valves characteristic of all *Bairdia* well developed (Pl. 14, figs. 1*a* and 1*h*); muscle scar pattern in an unusually deep pit which is very steep on its posterior side, sloping more gradually on the anterior side; muscle scar pit apparently a little deeper on the more tumid right valve.

Measurements of some of the figured specimens: Figure 1*a*, length 1.42 mm., height 0.83 mm.; figures 1*b–c*, length 1.35 mm., height 0.77 mm., width 0.56 mm.; figures 1*d–e*, length 1.30 mm.; height 0.75 mm., width 0.61 mm.; figure 1*f*, length 1.24 mm., height 0.75 mm. Length-height ratio varies from 1.65–1.76.

B. hispida Harlton, *B. wrefordensis* Upson, and *B. moorei* Knight were referred to *B. beedei* after an examination of the types. *B. hurwitzi* Coryell and Booth,[8] the type of which has not been seen, appears from the figure rather more elongate than *B. beedei*, but the length-height ratio of 1.7 given for *B. hurwitzi* is no greater than those of the specimens figures 1*c* and 1*e* of this paper which are 1.76 and 1.73 respectively. *B. hurwitzi* would have been placed in the synonomy of *B. beedei* except for the description of the dorsal channeling of *B. hurwitzi*. Judging by the figure and the length-height ratio of 1.51 the specimen referred to *B. hispida* Harlton by Coryell and Sample[9] is not conspecific with *B. beedei*.

[7] See Ulrich, E. O., and Bassler, R. S., *Idem.*, pl. 11, fig. 22.

[8] Coryell, H. N., and Booth, R. T., *Amer. Midland Nat.*, vol. 14, p. 262, pl. 3, figs. 8–9, 1933.

[9] Coryell, H. N., and Sample, C. H., *Am. Midland Nat.*, vol. 13, no. 5, p. 262, pl. 25, fig. 10, 1932.

EXPLANATION OF PLATE 14
All figures ×30

FIGS. 1*a–h*, 2—*Bairdia beedei* Ulrich and Bassler. Note variation in length-height ratio. 1*a*, 1*c*, 1*e*, 1*f*, and 1*h*, right side carapaces; 1*b* is the dorsal view of 1*c;* and 1*d* the dorsal view of 1*e;* 1*g* is a right valve. All from the Wreford formation at Loc. 57. The cyrioplesiotype is figured in 1*b–c*. Figure 2 is a cast showing the imprint of the muscle scar. (p. 123)

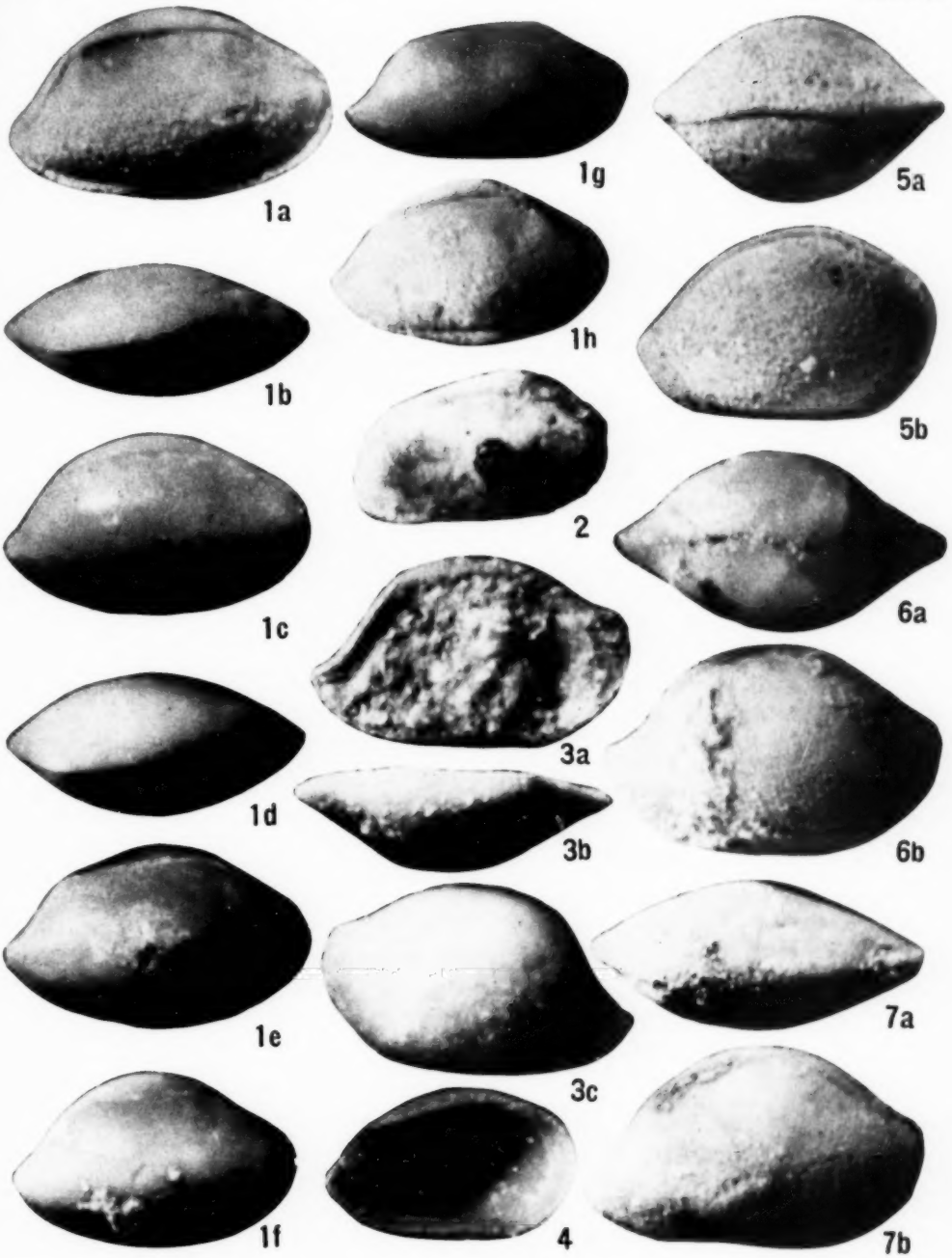
3*a–c*—*Bairdia radlerae* Kellett, n. sp. Interior, dorsal and exterior view of a left valve, the holotype, from the Neva formation, Loc. 67. (p. 125)

4—*Bairdia florenaensis* Upson. Interior left valve plesiotype to show the ventral groove characteristic of *Bairdia*. Cottonwood limestone, Loc. 44. (p. 137)

5*a–b*—*Bairdia hooverae* Kellett, n. sp. Dorsal view and right side carapace of the holotype from the Deer Creek formation, Loc. 17. (p. 126)

6*a–b*—*Bairdia deloi* Kellett, n. sp. Dorsal view and right side carapace of the holotype from the Elmdale formation, Loc. 64. (p. 126)

7*a–b*—*Bairdia eissensis* (?) Upson. Dorsal view and right side carapace of a specimen from the Wreford, Loc. 57. Post-ventral margin weathered. (p. 134)



Kellett, Pennsylvanian and Permian ostracodes

It has a lower posterior and a higher and more pointed anterior beak, a more arched dorsal hinge and a much smaller length-height ratio than even the shortest specimens of *B. beedei*.

B. beedei is characterized by its long convex, ventral margin, flat dorsal and ventral slopes, and the combination of strong dorsal apparent overlap and straight hinge forming a low, obtuse triangle in the dorsal area. The smaller *B. marmorea*, n. sp. (Pl. 15, figs. 1*a–h*), has a somewhat similar dorsal area and general shape, but the straight dorsal line of contact is shorter and the ends in both side and dorsal views are sharper than in *B. beedei*.

B. beedei occurs at least as low as the lower Marmaton, lower Middle Pennsylvanian; but it has not been found as low as the Boggy formation of middle Cherokee age in Oklahoma. It occurs in the Permian of Kansas as high as any ostracodes are found. It is a very common species, over eight hundred specimens having been picked from the Kansas collections. Stanton formation, Loc. 21 and 21 B, 3 specimens; Loc. 22, 1 specimen. Deer Creek formation, Loc. 17, 2 specimens; Loc. 18, 12 specimens. Topeka formation, Loc. 27, 1 specimen; Loc. 34, 10 specimens. Howard formation, Loc. 25, 1 specimen. Scranton shale, Loc. 30, 3 specimens. Wakarusa limestone, Loc. 15, 44 specimens. Falls City (?) limestone, Loc. 40, 89 specimens. Americus limestone, Loc. 70, 13 specimens. Elmdale formation, Loc. 41, 8 specimens; Loc. 41 A, 7 specimens; Loc. 60, 9 specimens; Loc. 60 X, 10 specimens; Loc. 64, 26 specimens; Loc. 65, 19 specimens. Neva formation, Loc. 66, 6 specimens, Loc. 67, 44 specimens; Loc. 42, 4 specimens. Cottonwood limestone, Loc. 73, common but only 8 picked out; Loc. 44, 42 specimens. Garrison formation, Loc. 59, 18 specimens. Wreford formation, Loc. 43, 56 specimens; Loc. 46, 24 specimens; Loc. 47, 26 specimens; Loc. 57, 48 specimens; Loc. 68, 20 specimens. Fort Riley limestone, Loc. 45, 198 specimens. Winfield formation, Loc. 56, 56 specimens, and Loc. 75, 11 specimens. Plesiotypes, U. S. Nat. Mus. Nos. 89463 (Pl. 14, figs. 1*a–b*) and 89488 (Pl. 14, fig. 2).

BAIRDIA RADLERAE Kellett, n. sp.
Plate 14, figures 3*a–c*

Bairdia pecosensis Delo, UPSON (not Delo), *1933*, Nebr. Geol. Survey, Bull. 8, 2d ser., p. 23, pl. 2, figs. 6*a–d*; Wreford formation, Permian; Marshall County, Kansas.

Carapace rather large; dorsal and ventral margins for the greater part almost parallel in lateral view; anterior beak high, above the mid-height of the valve and rounding broadly into the straight ventral margin; posterior beak well below the mid-height of the valve and fairly acuminate; antero-dorsal margin slightly concave; post-dorsal margin straight and steep; dorsal apparent overlap moderate; hinge line strongly angled at the post-dorsal corner.

Measurements of the holotype: Length, 1.38 mm.; height, 0.82 mm.

The posterior beak of *B. radlerae* is much lower than that of *B. deloi*, n. sp. (Pl. 14, figs. 6*a–b*) and it is less inflated. *B. radlerae* and *B. menardensis* Harlton[10] were differentiated only after topotype material of the latter had been examined when it was seen that the ends of *B. radlerae* are less compressed in dorsal view and less acute in side view. *B. garrisonensis* (Pl. 17, figs. 5*a–c*) does not have the parallel ventral and dorsal margins of *B. radlerae*. *B. radlerae* is less elongate and is higher anteriorly than *Bairdia* aff. *plebeia*, Girty,[11] of the Delaware Mountain formation of the Guadalupe Mountains.

The Wreford specimens (types examined) referred to *B. pecosensis* Delo are much less inflated than the type of *B. pecosensis* examined in Washington and they are less depressed at the hinge. It appears that the type of *B. pecosensis*

[10] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 158, pl. 4, figs. 1*a–d*, 1929.

[11] Girty, *U. S. Geol. Survey, Prof. Paper* 58, p. 16, pl. 25, figs. 16 and 16*a*, 1908.

because of the presence of cracks in the carapace combined with a compressed appearance may be a deformed specimen and the species therefore unrecognizable.

B. radlerae is characterized by its high anterior and low posterior beak and almost parallel ventral and dorsal margins.

Permian. Neva limestone, Loc. 67, 1 specimen. Wreford formation, Loc. 43, 4 specimens; Loc. 47, 2 specimens. Found also in the Wreford formation in deep wells. Holotype U. S. Nat. Mus. No. 89464.

The name is in honor of Miss Dollie Radler of the Amerada Petroleum Corporation, Tulsa, Oklahoma.

BAIRDIA HOOVERAE Kellett, n. sp.
Plate 14, figures 5*a–b*

Carapace short, high, and strongly inflated; greatest thickness in the central part of valve near the venter; venter so broad and flat that specimens will easily stand alone on it; carapace in end view resembling an equilateral triangle with slightly inflated sides; in lateral view dorsal margin arched; ventral margin long and straight; anterior beak broadly rounded with the apex above the mid-height of the valve; posterior beak blunt, located just below the mid-height; dorsal apparent overlap narrow and even.

Measurements of the holotype: Length 1.30 mm.; height, 0.82 mm.; width 0.79 mm.

B. hooverae has a longer, straighter margin in side view than either *B. blakei* Harlton[12] or *B. coryelli* Roth and Skinner,[13] and the greatest inflation is located ventrally rather than near the center of the valve.

B. hooverae is characterized by its extreme inflation and very broad, flat venter.

Pennsylvanian, Shawnee group. Oread (?) limestone, Loc. 24, 4 specimens; Deer Creek formation, Loc. 17, 4 specimens; found also in the Shawnee in deep wells. In the Stanton limestone, upper Missouri series, several single valves occurred which are apparently of *B. blakei* Harlton, but which might possibly be somewhat mashed specimens of *B. hooverae* (Loc. 22, 6 specimens; Loc. 23, 1 specimen). Holotype U. S. Nat. Mus. No. 89465.

The name is in honor of Mrs. Herbert Hoover; and the holotype is from the Deer Creek formation, a correlative of the Pawhuska limestone formation of Oklahoma first found[14] by ex-President Herbert Hoover.

BAIRDIA DELOI Kellett, n. sp.
Plate 14, figure 6*a–b*

Bairdia blakei Harlton, UPSON (not Harlton), *1933*, Nebr. Geol. Survey, Bull. 8, 2d ser., pp. 21–22, pl. 2, figs. 1*a–b;* lower Wreford formation, Permian; Kansas.

Carapace large; in lateral view dorsal and ventral margins broadly and somewhat flatly arched; beaks short and bluntly acuminate, the anterior located just above and the posterior just below the mid-height of the valve; post-dorsal margin short and very concave; greatest height central; carapace in dorsal view spindle shaped with a strongly inflated central portion; apparent overlap narrow.

Measurements of the holotype: Length, 1.47 mm.; height, 0.90 mm.; width 0.77 mm. One specimen found was a little shorter than the holotype.

An examination of types referred by Upson to *B. blakei* shows that they are much more elongate and less inflated than either the holotype or the original figure of *B. blakei* and are not conspecific with *B. blakei*. *B. deloi* has a much higher posterior beak than either *B. menardensis* Harlton[15] or *B. radlerae* Kellett, n. sp. (Pl. 14, figs. 3*a–3c*).

B. deloi is characterized by moderate inflation and blunt beaks, each located near the mid-height of the valve.

[12] Harlton, B. H., *Jour. Paleontology*, vol. 2, p. 139, pl. 21, fig. 12, 1928. *Idem.*, vol. 5, p. 163, 1931.

[13] Roth, R., and Skinner, J., *Jour. Paleontology*, vol. 4, pp. 334, 352, pl. 28, figs. 12–14, 1930. *Idem.*, vol. 5, p. 48, 1931.

[14] Gould, Charles N., *Okla. Geol. Survey, Bull.* 35, p. 78, 1925.

[15] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 158, pl. 4, figs. 1*a–d*, 1929.

Lower Permian. Elmdale formation, Loc. 41, 1 specimen; Loc. 64, 2 specimens. Found also in the Cottonwood limestone in deep wells. Holotype U. S. Nat. Mus. No. 89466.

The name is in honor of Mr. David M. Delo of Harvard University.

BAIRDIA MARMOREA Kellett, n. sp.
Plate 15, figures 1*a–h*

Carapace rather small; in lateral view anterior end narrowly rounded and slightly above the mid-height of the valve; posterior end pointed and slightly below the mid-height; dorsal and ventral margins evenly arched; greatest height slightly anterior to the center; in dorsal view ends evenly tapered; dorsal line of contact of the valves very slightly if at all depressed and straight in the central part rather than arched.

Measurements of the figured specimens: Figure 1*a*, length 1.10 mm., height 0.60 mm.; figure 1*b*, length 1.07 mm., height 0.59 mm.; figure 1*c–d*, length 1.06 mm., height 0.58 mm., width 0.39 mm.; figure 1*e*, length 1.01 mm., height 0.58 mm.

B. marmorea is more tapering than *B. beedei* in both side and dorsal views, and is less elongate than *B. conilata* Harlton.[16]

Lower Middle Pennsylvanian to Permian. Occurs in deep well samples as low as the lower part of the Missouri series. Extends into the Permian as high as the Winfield limestone, the uppermost limestone of the Permian commonly carrying microfossils. Wakarusa limestone, Loc. 15, 8 specimens. Falls City (?) limestone, Loc. 40, 7 specimens. Americus limestone, Loc. 70, 1 specimen. Elmdale formation, Loc. 60 X, 8 specimens. Loc. 64, 20 specimens; Loc. 65, 13 specimens. Neva formation, Loc. 42, 2 specimens; Loc. 67, 2 specimens. Cottonwood limestone, Loc. 73, 2 specimens. Garrison formation, Loc. 59, 2 specimens. Wreford formation, Loc. 43, 2 specimens; Loc. 46, 4 specimens; Loc. 47, 10 specimens; Loc. 57, 16 specimens. Fort Riley formation, Loc. 45, 1 specimen. Winfield formation, Loc. 75, 10 specimens. Holotype U. S. Nat. Mus. No. 89467*a*; paratypes, No. 89467*b-f*.

[16] Harlton, B. H., *Am. Jour. Sci.*, vol. 18, p. 268, Sept., 1929.

BAIRDIA SEMINALIS Knight
Plate 15, figures 2*a–c*

Bairdia seminalis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 320, pl. 43, figs. 2*a–d*; lower Marmaton, St. Louis and St. Louis County, Missouri.

Bairdia crassa Harlton, DELO (not Harlton, 1929), *1930*, Jour. Paleontology, vol. 4, p. 164, pl. 12, fig. 15. *1931*, Washington Univ. Studies, n. ser., Science and Technology, no. 5, p. 49, pl. fig. 9.

Bairdia samplei CORYELL AND BOOTH, *1933*, Am. Midland Nat., vol. 14, no. 3, p. 264, pl. 3, figs. 12, 13; Wayland shale, Graham County.

Bairdia tumida UPSON, *1933*, Nebr. Geol. Survey, Bull. 8, 2d ser., p. 21, pl. 2, figs. 3*a–c*; Cottonwood-Florena contact; Permian, Kansas (types examined).

Carapace small, short and thick; dorsal margin strongly arched; anterior beak broad and rather blunt; posterior beak bluntly acuminate; anterior beak slightly above, and posterior beak slightly below the mid-height of the valve; greatest height just anterior to the center; dorsal apparent overlap very high and conspicuous especially in the mature molts.

Measurements of the figured specimens: 2*a*, *b*, length 0.99 mm., height 0.68 mm., width 0.48 mm.; 2*c*, length 1.02 mm., height 0.64 mm.

The specimens in my collection were referred to *B. seminalis* after an examination of topotype material which included not only the holotype of *B. seminalis* but also an unfigured paratype, a larger and more mature molt than the holotype, which closely resembles the Upper Pennsylvanian forms. The holotype of *B. ciscoensis* Harlton[17] shows a more pointed and upturned anterior than does *B. seminalis*. *B. seminalis* differs from *B. crassa* Harlton[18] in the lesser inflation in dorsal view, in the stronger ap-

[17] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 210, pl. 33, fig. 8, 1927.

[18] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 158, pl. 4, figs. 3*a–c*, 1929.

parent dorsal overlap, and in the much less narrowly pointed posterior beak. *B. seminalis* resembles *B. compacta* Geis[19] much in outline and strong dorsal apparent overlap but the dorsum of *B. seminalis* is more arched in lateral view.

B. seminalis occurs as low as the middle Des Moines series, Lower Pennsylvanian and extends up into the Neva formation of the Permian, with some doubtful poorly preserved specimens in the Wreford. It does not occur as low as the Boggy formation in Oklahoma, the somewhat similar form occurring in the Boggy tapering more in both side and dorsal views. Stanton limestone, Loc. 21, 1 specimen; Loc. 22, 16 specimens; Loc. 23, 3 specimens. Oread (?) limestone, Loc. 24 A, 2 specimens. Common in the Shawnee formation. Deer Creek formation, Loc. 17, 34 specimens; Loc. 18, 11 specimens. Topeka formation, Loc. 26, 8 specimens; Loc. 27, 12 specimens; Loc. 34, 16 specimens. Howard formation, Loc. 25, 35 specimens. Burlingame limestone, Loc. 16, 42 specimens, Loc. 71, 20 specimens. Wakarusa limestone, Loc. 15, 29 specimens. Emporia limestone, Loc. 69, 17 specimens. Falls City (?) limestone, Loc. 40, 26 specimens. Americus limestone, Loc. 70, 16 specimens. Elmdale formation, Loc. 60, 27 specimens; Loc. 60 X, 10 specimens; Loc. 41, 3 specimens; Loc. 41 A, 7 specimens. Neva limestone, Loc. 66, 12 specimens; Loc. 67, 21 specimens. Wreford formation, Loc. 43, 8 poorly preserved specimens doubtfully belonging to this species. Plesiotypes U. S. Nat. Mus. No. 89468.

[19] Geis, Harold, *Jour. Paleontology*, vol. 6, p. 177, pl. 25, figs. 14*a–d*, 1932.

BAIRDIA KANSASENSIS Kellett, n. sp.
Plate 15, figures 3*a–b* (?), figures 4*a–b*

Carapace medium sized; lanceolate in dorsal view with compressed ends; in lateral view the straight median portion of the dorsal margin almost parallels the ventral margin; dorsal slopes long and of almost equal length; anterior beak sharply rounded and very low, below the mid-height of the valve; posterior beak short and stout, just below the mid-height; dorsal apparent overlap only slightly depressed, rather narrow and of equal width from one extremity of the valve to the other.

Measurements of the figured specimens: 3*a–b*, length 1.17 mm., height 0.62 mm., width 0.48 mm.; 4*a–b*, length 1.30 mm., height 0.68 mm.

B. kansasensis has a lower posterior beak than *B. summa* Coryell and Billings,[20] also a more angulated dorsal hinge contact and a longer, straighter venter. The posterior beak is sharper than that of *B. grahamensis* Harlton,[21] both the anterior and posterior beaks are much lower, and *B. kansasensis* is much larger. It lacks the "pronounced convexity" which Harlton gives in his description of

[20] Coryell, H. N., and Billings, Gladys, *Am. Midland Nat.*, vol. 13, p. 170, pl. 17, fig. 1, 1932.

[21] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 139, pl. 21, fig. 11, 1928; *Texas Univ., Bull.* 2901, p. 156, pl. 3, fig. 4, 1929.

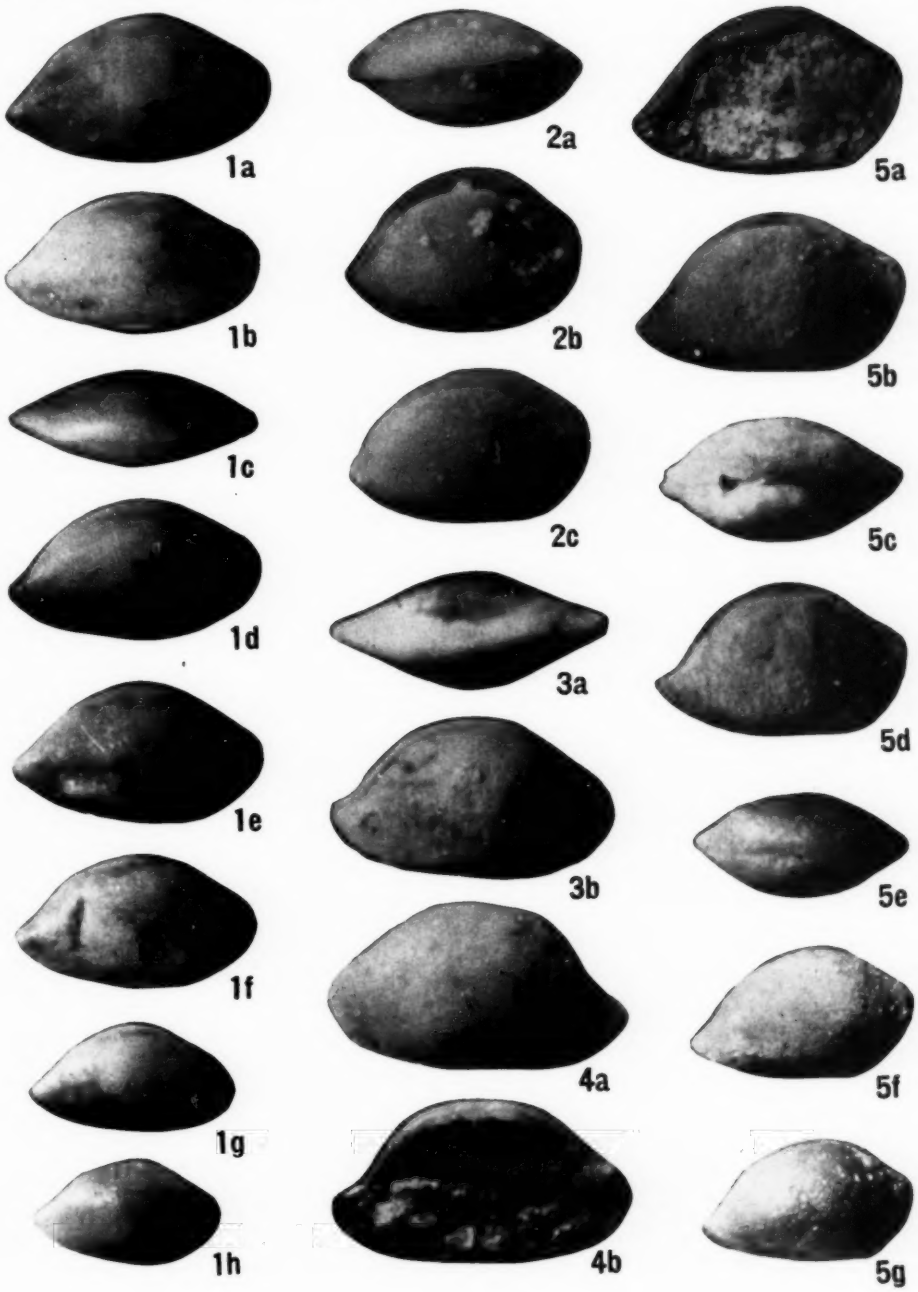
EXPLANATION OF PLATE 15
All figures ×30

FIGS. 1*a–h*—*Bairdia marmorea* Kellett, n. sp. All right sides of carapaces except 1*c* which is the dorsal view of the holotype, 1*d*. Wreford formation, Loc. 57. (p. 127)

2*a–c*—*Bairdia seminalis* Knight. 2*b–c*, right sides carapaces, 2*a* is the dorsal view of 2*b*. 2*c* is the cyrioplesiotype. Elmdale formation, Loc. 41 A. (p. 127)

3*a–b*, 4*a–b*—*Bairdia kansasensis* Kellett, n. sp. 3*a–b* (?) dorsal view and right side carapace from the Elmdale formation, Loc. 65. 4*a–b*, left valve, holotype, from the Stanton limestone, Loc. 22. (p. 128)

5*a–g*—*Bairdia crassa* (?) Harlton. 5*a*, interior left valve. 5*b*, right side carapace, cyrioplesiotype; 5*c*, dorsal view of 5*d*; 5*e* dorsal view of 5*f*. Oread formation or possibly a little lower, Loc. 24. (p. 129)



Kellett, Pennsylvanian and Permian ostracodes

B. menardvillensis (formerly *B. marginata* Harlton),[22] and the beaks are also lower than those of *B. menardvillensis*. It has a lower anterior beak and a less arched dorsum than *B. eissensis* Upson. The holotype of *B. irionensis* Delo[23] was examined and was found to be more rotund than *B. kansasensis* and to have a depressed hinge. *B. kansasensis* is characterized by its very low anterior beak.

Middle Pennsylvanian. Stanton limestone, Loc. 22, 1 specimen. The figured specimen from the Permian Elmdale formation is questionably referred to this species because the anterior beak is a little higher than that of *B. kansasensis*. Holotype U. S. Nat. Mus. No. 89469; other specimen, No. 89489.

BAIRDIA CRASSA (?) Harlton
Plate 15, figures 5*a–g*

Bairdia crassa HARLTON, *1929*, Texas Univ., Bull. 2901, p. 158, pl. 4, figs. 3*a–b*, (3*c*?); Graham formation, Middle Pennsylvanian; Menard County, Texas.

Carapace medium-sized, high, and inflated; anterior beak high and somewhat acuminate; posterior beak low and pointed; ventral margin long and straight; hinge line distinctly angled at the antero- and post-dorsal corners; dorsal apparent overlap of the larger valve great (see fig. 5*a*), but not conspicuous in lateral view (see fig. 5*b*) because of the pronounced dorsal inflation of the right valve extending well above the hinge line; hinge line very deeply depressed (see fig. 5*c*).

Measurements of the figured specimens: Figure 5*a*, length, 1.09 mm., height, 0.68 mm.; figure 5*b*, length 1.14 mm., height, 0.65 mm.; figures 5*c–d*, length, 1.05 mm., height, 0.62 mm., width 0.52 mm.; figure 5*e–f*, length 0.94 mm., height, 0.53 mm., width 0.42 mm.

The specimens herein figured appear to have more acuminate anterior beaks than *B. crassa* Harlton which occurs at about the same stratigraphic horizon in Texas; however, one specimen was found in my material which was a little shorter than those figured and which, therefore, resembled the figures of *B. crassa* very closely. I would not include in this species the specimen from the Holdenville of Oklahoma.[24]

Middle Pennsylvanian Oread (?) limestone, Loc. 24, 23 specimens; Stanton limestone, Loc. 22, 4 specimens. Plesiotypes U. S. Nat. Mus. No. 89470.

BAIRDIA VERWIEBEI Kellett, n. sp.
Plate 16, figures 1*a–h*; Plate 17, figures 2*a–c*(?)

Carapace small, somewhat elongate; anterior beak rather narrow; slightly above the mid-height of the valve; posterior beak low and bluntly acuminate; dorsal and ventral margins long, almost straight and parallel in the medium portions; post-dorsal margin short and steep; carapace in dorsal view rather thin with spindle-like ends; dorsal apparent overlap conspicuous; hinge line not depressed. The earlier molts are more tumid centrally and more pointed at the extremities than the mature molts.

Measurements of the figured specimens: Plate 16, figure 1*a–b*, length 0.98 mm., height 0.50 mm., width 0.35 mm.; 1*c–d*, length 0.95 mm., height 0.47 mm., width 0.33 mm.; 1*e*, length 0.88 mm., height 0.42 mm.; Plate 17, figure 2*a–b*, length 0.98 mm., height 0.48 mm., width 0.32 mm., 2*c*, length 0.97 mm., height 0.45 mm.

The specimens very doubtfully referred to this species, Plate 17, figure 2*a–c*, are more elongate and appear to have stouter posterior beaks in lateral view than the types. These specimens superficially resemble the young of *B. reussiana* (Pl. 17, fig. 1*a–h*) but are less elongate and have higher anterior beaks and lower posterior beaks than *B. reussiana*. Weathered specimens of an undescribed form quite close to *B. verwiebei* were found in the Middle Pennsylvanian Deer Creek formation. These however had a wider carapace. Compared

[22] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 158, pl. 4, fig. 2, 1929; *Jour. Paleontology*, vol. 5, p. 163, 1931.

[23] Delo, David M., *Jour. Paleontology*, vol. 4, p. 165, pl. 12, fig. 18, 1930.

[24] Warthin, Aldred S., *Okla. Geol. Survey, Bull.* 53, p. 71, pl. 4, figs. 1*a–b*, 1930.

with *B. pompilioides* Harlton (Pl. 16, fig. 2*a*–4*b*), *B. verwiebei* is smaller and the beaks are lower or nearer the venter, less pointed, and less upturned.

Permian. Neva limestone, Loc. 67, 2 specimens (?). Wreford formation, Loc. 43, 1 specimen; Loc. 46, 1 specimen; Loc. 47, 31 specimens, Loc. 57, 9 specimens. Fort Riley limestone, Loc. 45, 12 specimens. Winfield formation, Loc. 75, 1 specimen. Holotype U. S. Nat. Mus. No. 89471*a*; paratypes No. 89471*b*–*f*, specimens figured Plate 17, figure 2*a*–*c*, No. 89472.

The name is in honor of Dr. Walter A. Ver Wiebe of Wichita University, Wichita, Kansas.

BAIRDIA POMPILIOIDES Harlton
Plate 16, figures 2*a*–*b*, 3*a*–*b*, 4*a*–*b*,

Bairdia pompilioides HARLTON, *1928*, Jour. Paleontology, vol. 2, p. 140, pl. 21, fig. 13; Hoxbar (?)[25] formation; Carter County, Oklahoma. *1929*, Texas Univ., Bull. 2901, p. 154, pl. 2, fig. 7, pl. 3, fig. 8; Graham formation; Menard County, Texas. WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 70, pl. 5, figs. 11*a*, *b*; Holdenville formation, eastern Oklahoma. CORVELL and OSORIO, *1932*, Am. Midland Nat., vol. 13, no. 2, p. 33; Nowata shale, Marmaton; Tulsa County, Oklahoma.

Bairdia subcitriformis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 322, pl. 43, figs. 5*a*, *b*; lower Pawnee limestone, St. Louis County, Missouri.

[25] Tomlinson, C. W., *Okla. Geol. Survey, Bull.* 46, p. 78, 1929.

Carapace elongate, dorsal view slender and spindle shaped with sides somewhat flattened; in lateral view ends elongate, pointed and slightly upturned, dorsum and venter broadly rounded, central part of venter almost straight or slightly concave; dorsal overlap long and usually fairly wide.

Measurements of figured specimens: Plate 16, figure 2*a*–*b*, length 1.42 mm., height 0.62 mm., width 0.43 mm.; figures 3*a*–*b*, length 1.29 mm., height 0.64 mm., width 0.47 mm.; figures 4*a*–*b*, length 1.47 mm., height 0.77 mm., width 0.52 mm.

The specimen, figure 2*a*–*b*, is the longest found; the lateral outline is very similar to that of *B. peracuta* Warthin[26] from the Holdenville formation but that species lacks the definite dorsal overlap shown in figure 2. *B. pompilioides*, figure 4*a*–*b*, which is a little higher than any other specimen as yet figured, is much more common in the Elmdale formation than the typical, more elongate form.

The species *B. pompilioides* seems to have gradually decreased in size from the lower Middle Pennsylvanian to the Permian; a collection of five specimens from the Holdenville formation of Oklahoma are all larger than the nine specimens from the Wreford formation, Permian; and the largest specimens of the Kansas collection are from the lowest formation, the Stanton.

[26] Warthin, Aldred S., *Okla. Geol. Survey, Bull.* 53, p. 71, pl. 6, figs. 2*a*–*b*, 1930.

EXPLANATION OF PLATE 16
All figures ×30

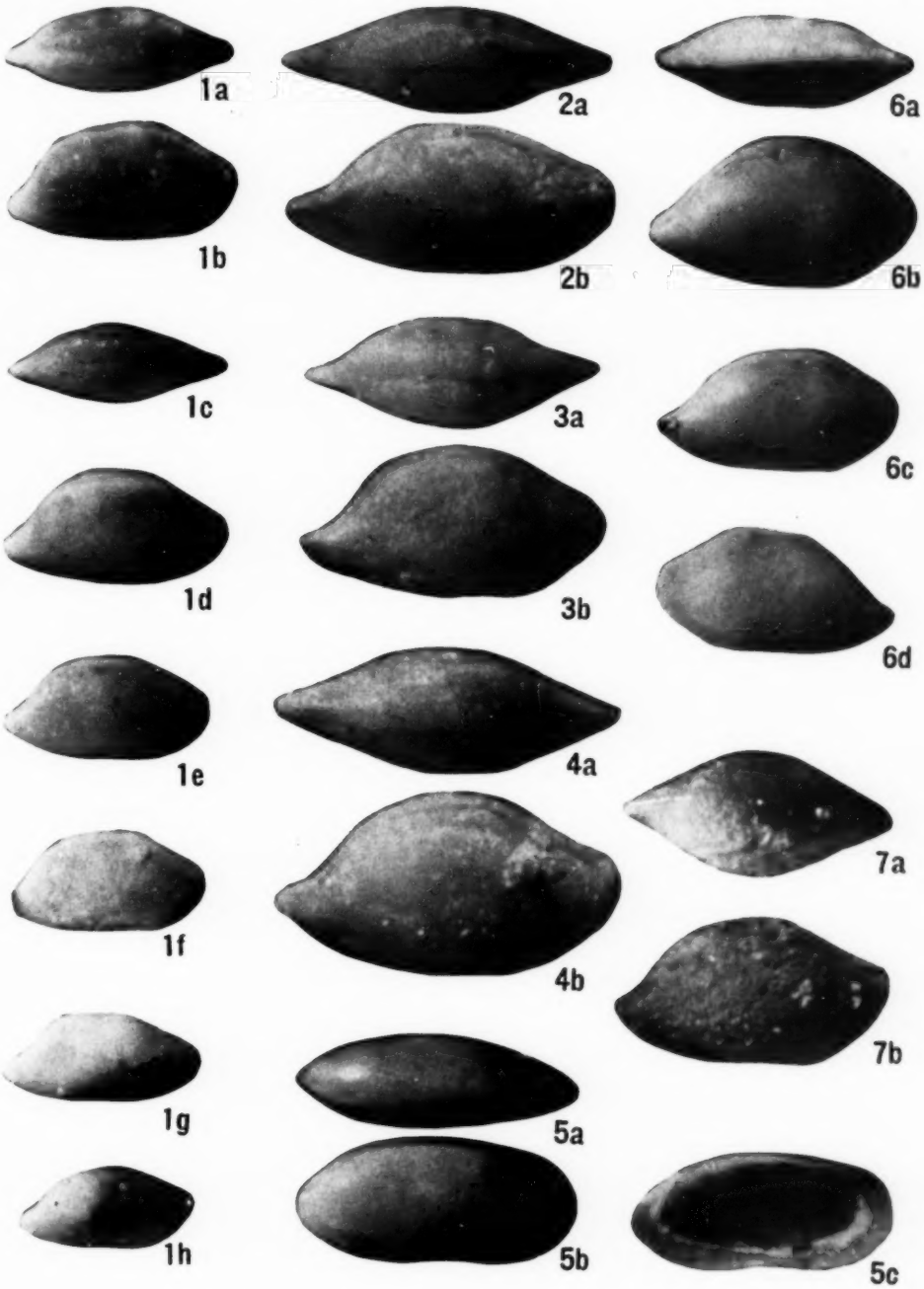
FIGS. 1*a*–*h*—*Bairdia verwiebei* Kellett, n. sp. 1*a*–*b*, dorsal view and right side carapace, holotype. 1*c* is the dorsal view of 1*d*. 1*d*–1*h*, right sides carapaces. Wreford formation, Loc. 47. (p. 129)

2*a*–4*b*—*Bairdia pompilioides* Harlton. 2*a*–*b*, dorsal view and right side carapace of an unusually elongate specimen, Wakarusa limestone, Loc. 15. 3*a*–*b*, dorsal view and right side carapace, Wreford formation, Loc. 43. 4*a*–*b*, dorsal view and right side carapace, Elmdale formation, Loc. 60 X. (p. 130)

5*a*–*c*—*Bairdia hoxbarensis* Harlton. 5*a*–*b*, dorsal view and right side carapace, cyrioplesiotype. 5*c*, interior left valve. Elmdale formation, Loc. 61. (p. 131)

6*a*–*d*—*Bairdia perincerta* Kellett, n. sp. 6*a*–*b*, dorsal view and right side carapace holotype. 6*c*–*d*, right and left side of a carapace. Note dorsal ridge on left valve. Burlingame limestone, Loc. 71. (p. 132)

7*a*–*b*—*Bairdia geisi* Kellett, n. sp. Dorsal view and right side carapace, holotype. Elmdale formation, Loc. 64. The rough surface is due to weathering. (p. 132)



Kellett, Pennsylvanian and Permian ostracodes

B. subcitriformis Knight was referred to *B. pompilioides* after examining the holotype. Knight's photograph of this specimen shows a ventral rounding, but this proves to be due to a slight weathering of the post-ventral portion of the holotype.

Lower Marmaton group, Pennsylvanian, to the Wreford formation of the Permian. Stanton limestone, Loc. 12, 1 specimen; Loc. 21 B, 2 specimens. Oread (?) limestone, Loc. 24 X, 1 specimen. Topeka formation, Loc. 27, 1 specimen. Wakarusa limestone, Loc. 15, 3 (?) specimens. Emporia limestone, Loc. 69, 1 specimen. Americus limestone, Loc. 70, 11 specimens. Elmdale formation, Loc. 60, 3 specimens; Loc. 60 X, 3 specimens; Loc. 61, 4 specimens; Loc. 64, 7 specimens; Loc. 41 A, 2 specimens. Wreford formation, Loc. 43, 9 specimens. Plesiotypes U. S. Mat. Mus. Nos. 89473 (Loc. 15), 89490 (Loc. 43), and 89491 (Loc. 60 X).

BAIRDIA HOXBARENSIS Harlton
Plate 16, figures 5*a–c*

Bairdia hoxbarensis HARLTON, *1927*, Jour. Paleontology, vol. 1, p. 211, pl. 33, fig. 12; Hoxbar (?)[27] Pennsylvanian, Carter County, Oklahoma. (Not Harlton, *1929*, Texas Univ., Bull. 2901, p. 154, pl. 3, figs. 1*a–d;* Graham formation, Menard County, Texas.)

Bairdia haworthi KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 325, pl. 43, figs. 7*a, b;* lower Marmaton, St. Louis County, Missouri; holotype examined.—WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 72, pl. 6, figs. 4*a, b;* Wetumka to Holdenville formations, Oklahoma.

Bairdia subelongata (not Jones and Kirkby), HARLTON, *1927*, Jour. Paleontology, vol. 1, pp. 210–11, pl. 33, fig. 11; upper Glenn formation, Carter County, Oklahoma; type examined.—KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 326, pl. 43, fig. 9; lower Marmaton, St. Louis County, Missouri; type examined.—HARLTON, *1929*, Texas Univ., Bull. 2901, p. 157, pl. 3, figs. 6*a–d;* Graham formation; Menard County, Texas; type examined.

Bairdia acetalata CORYELL AND BILLINGS, *1932*, Am. Midland Nat., vol. 13, no. 4, p. 173, pl. 17, fig. 5; Wayland shale, Graham formation; Texas; holotype examined.—CORYELL AND BOOTH, *1933*, Am. Midland Nat., vol. 14, no. 3, p. 263, pl. 3, figs. 10, 11; Wayland shale; Texas.—UPSON, *1933*, Nebr. Geol. Survey, 2d ser., Bull. 8, p. 17, pl. 1, fig. 5*a;* Eiss limestone, Garrison formation; Nebraska.

Bairdia nebraskensis UPSON, Nebr. Geol. Survey, 2d ser., Bull. 8, p. 18, pl. 1, figs. 6*a–b;* Fourmile limestone, Wreford formation; Kansas.

Warthin[28] noted that "the specimens described by Harlton from Menard County and referred to his *B. hoxbarensis* have little resemblance either to his original figure of that species or to the holotype in the National Museum and should be referred to *B. altifrons.*" A further examination of the holotype of *B. hoxbarensis* at the National Museum by Doctor Bassler and myself brought to light the fact that the photograph of the supposed holotype of *B. hoxbarensis* in the Menard County bulletin is mislabeled and is not a photograph of the holotype of *B. hoxbarensis*, but is in all probability a photograph of the holotype of *B. texana* Harlton. The holotype of *B hoxbarensis* is quite elongate as is shown in the original drawing by Harlton.[29] Examination of the types of *B. frumentum* Reuss[30] from the Upper Permian of Europe might reveal that *B. hoxbarensis* should be referred to this species.

Measurements of the figured specimens from the Elmdale formation: Figures 5*a–b*, length 1.18 mm., height 0.52 mm., width 0.39 mm.; figure 5*c*, length 1.09 mm., height 0.48 mm.

B. hoxbarensis extends from at least as low in the Pennsylvanian as the lower Marmaton group up into the Permian Wreford formation. Stanton limestone, Loc. 21 B, 14 specimens; Loc. 22, 2 specimens; Loc. 22 B, 1 specimen; Loc. 23, 1 specimen. Topeka formation, Loc. 34, 1 specimen. Howard formation, Loc. 25, 1 specimen. Burlingame limestone, Loc. 16, 3 specimens, Loc. 71, 5 specimens.

[27] *Idem*

[28] Warthin, Aldred S., *Okla. Geol. Survey, Bull.* 53, p. 70, 1930.

[29] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 210, pl. 33, fig. 9, 1927.

[30] Reuss, A. E., *Jahrb. Wett. Ges. etc.*, pp. 59–77, pl. figs. 8*a b*, 1854.

Wakarusa limestone, Loc. 15, 9 specimens. Emporia limestone, Loc. 69, 4 specimens. Falls City (?) limestone, Loc. 40, 23 specimens. Elmdale formation, Loc. 60, 4 specimens; Loc. 60 X, 12 specimens: Loc. 61, 7 specimens; Loc. 64, 32 specimens; Loc. 65, 7 specimens. Neva limestone, Loc. 42, 1 specimen (?); Loc. 66, 1 specimen; Loc. 67, 4 specimens. Cottonwood limestone, Loc. 44, 3 specimens. Wreford formation, Loc. 43, 4 specimens. Plesiotypes U. S. Nat. Mus. No. 89474.

BAIRDIA PERINCERTA Kellett, n. sp.
Plate 16, figures 6*a–d*

Carapace moderately high in side view; anterior beak narrowly rounded and high; posterior beak low and pointed; medium part of dorsal margin straight; in dorsal view sides flattened and ends pointed; a narrow horizontal dorsal ridge on the left valve (see figures 6*a*, 6*d*).

Measurements of the figured specimens: Figure 6*a–b*, length 1.14 mm., height 0.62 mm., width 0.37 mm.; figures 6*c–d*, length 1.01 mm., height 0.52 mm.

The only other species on which this prominent dorsal ridge has been noted is *B. powersi*, n. sp., Plate 17, figures 6*a–e*, which in lateral view has a much lower anterior beak and a much steeper postdorsal slope than *B. perincerta*. The ends of *B. perincerta* are more pointed in side view than those of *B. oklahomaensis* Harlton.[31] Immature specimens resemble *B. marmorea*, n. sp. in overlap and in lateral outline, but *B. perincerta* is shorter with a straighter dorsum and venter.

Upper Pennsylvanian, Wabaunsee group. Howard formation, Loc. 25, 3 specimens. Burlingame limestone, Loc. 71, 1 specimen. Holotype, U. S. Nat. Mus. No. 89475*a*; paratype, No. 89475*b*.

BAIRDIA GEISI Kellett, n. sp.
Plate 16, figures 7*a*, *b*

Carapace rather elongate; in dorsal view inflated with evenly tapering ends; anterior beak very high and narrowly rounded, slightly upturned; posterior beak very low and short; venter long and slightly concave; dorsum broadly rounded; dorsal apparent overlap slight. Measurements of the holotype: length 1.15 mm., height 0.62 mm., width 0.52 mm.

B. geisi is shorter and more inflated than *B. pompiloides* Harlton (Pl. 16, figs. 2*a*–4*b*).

Permian. Elmdale formation, Loc. 64, 1 specimen; Cottonwood limestone, Loc. 73, 1 specimen; Wreford formation, Loc. 43, 1 specimen. Holotype U. S. Nat. Mus. No. 89476.

The name is in honor of Mr. Harold H. Geis of the University of Chicago, who is describing many of the Carboniferous ostracodes of Indiana and Illinois.

BAIRDIA REUSSIANA Kirkby
Plate 17, figures 1*a–h*, 4*a–b*

Bairdia reussiana KIRKBY, *1858*, Annals and Mag. Nat. Hist., vol. 2, p. 319, pl. 10, figs. 6, 6*a*. *1859*, Trans. Tynside Nat. Field Club, vol. 4, p. 146, text fig. 8, pl. 9, fig. 6. Durham limestone, Permian; England.—UPSON, *1933*, Nebr. Geol. Survey, Bull. 8, 2d ser., p. 19, pl. 2, fig. 2*a*; Fourmile limestone, Wreford formation, Permian; Kansas.

Bairdia maxeyi HARRIS AND LALICKER, *1932*, Am. Midland Nat., vol. 13, p. 405, pl. 37, fig. 9; Crouse limestone, Garrison shale, Permian; Cowley County, Kansas.

Bairdia matfieldensis UPSON, *1933*, Am. Midland Nat., p. 18, pl. 1, figs. 7*a–b*; Kinney limestone, Matfield shale formation, Permian; Nebraska.

Carapace elongate tapering; anterior beak broad and blunt with rather square corners; posterior beak high and blunt; greatest height anterior to the center; antero-dorsal slope in side view slightly depressed; apparent overlap narrow.

Measurements of the figured specimens: Figures 1*a*, *b*, length 1.34 mm., height 0.61 mm., width 0.41 mm.; figure 1*c*, length 1.34 mm., height 0.63 mm.; figure 1*d*, length 1.23 mm., height 0.55 mm.; figures 4*a–b*, length 1.31 mm., height 0.56 mm., width 0.35 mm.

The elongate variations which are figured in 4*a–b* were seen in only the Elm-

[31] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 156, pl. 3, figs. 5*a*, *b*, 1929.

dale formation and the Cottonwood limestone at Locs. 60 and 44.

The specimens here referred to *B. reussiana* differ from the type figure only in the slight antero-dorsal concavity of some of the American forms. They are more arched dorsally and more tapering both anteriorly and posteriorly than *B. hextensis* Harlton.[32]

A few rare and doubtful specimens of *B. reussiana* were found in the Pennsylvanian. It is found in the Permian from the Americus to the Winfield formations, being abundant in the Wreford formation. In the Stanton formation, Loc. 21 B, 2 specimens were found which agreed in outline with the adult *B. reussiana* but were only about as large as the smallest specimens figured in this paper. In the Wakarusa limestone Loc. 15, 2 broken specimens occurred which appeared to be *B. reussiana*. Americus limestone, Loc. 70, 3 specimens. Elmdale formation, Loc. 60, 5 specimens; Loc. 61, 4 specimens; and Loc. 64, 4 specimens. Neva formation, Loc. 67, 2 specimens. Cottonwood formation, Loc. 44, 21 specimens; Loc. 73, 3 specimens. Garrison formation, Loc. 58, 2 specimens; Loc. 59, 4 specimens. Wreford formation, Loc. 43, 10 specimens; Loc. 57, 44 specimens, and Loc. 47, 8 specimens. Fort Riley limestone, Loc. 45, 22 specimens. Winfield formation, Loc. 75, 7 specimens. Plesiotypes U. S. Nat. Mus. Nos. 89477 (Loc. 44) and 89492 (Loc. 47).

BAIRDIA HOFFMANAE Kellett, n. sp.
Plate 17, figure 3

Carapace elongate; anterior beak narowly rounded; posterior beak blunt; beaks both very near the venter; venter long and straight with a slight central indentation; dorsum arched and rounding evenly down toward the venter like a bow; dorsal apparent overlap narrow; carapace in dorsal view resembles closely *B. reussiana*.

Measurements of the figured specimen: Length 1.43 mm., height 0.70 mm.

[32] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 157, pl. 3, fig. 9, 1929.

B. hoffmanae differs from *B. reussiana* Kirkby, Plate 17, figures 1*a–h*, in the lower and less upturned ends and the larger size. *B. hoffmanae* may be the same species as that from the Permian, upper Durham limestone of England referred by Kirkby to *B. kingi* Reuss;[33] however, this English specimen does not appear to be conspecific with the type of *B. kingi* figured by Reuss.[34]

Basal Permian, Americus limestone; Loc. 70, 1 specimen. Holotype U. S. Nat. Mus. No. 89478.

The name is in honor of Miss Olive Hoffman of the Phillips Petroleum Company, Wichita, Kansas.

BAIRDIA POWERSI Kellett, n. sp.
Plate 17, figures 6*a–e*

Carapace small; in dorsal view sides parallel, ends compressed; in lateral view subrhomboidal; dorsal and ventral margins almost parallel; anterior beak very narrowly rounded, at the mid-height of the valve; posterior beak low and blunt; apparent overlap narrow and even; the left valve carrying a small horizontal ridge near its dorsal edge, see Plate 17, figures 6*b*, 6*c* and 6*e*.

Measurements of the figured specimens: Figure 6*a*, *b*, length 1.06 mm., height 0.61 mm.; figure 6*c*, *d*, length 1.15 mm., height 0.41 mm.

B. powersi resembles in lateral view *B. grahamensis* Harlton[35] but the beaks of *B. powersi* are narrower and more pointed and the posterior beak is lower. It is much less convex than *B. menardensis* Harlton[36] and *B. menardvillensis*[37] Harlton. Furthermore none of the above species have the slight dorsal ridge on the left valve which is seen only on *B. powersi* and *B. perincerta*, n. sp.

[33] Kirkby, J. W., *Annals and Mag. Nat. Hist.*, 3, vol. 2, pp. 317–30, pl. 10, figs. 8–8*a*, 1858.

[34] Reuss, A. E., *Jahr. Wett. Ges.*, pp. 59–77, pl. fig. 4, 1854.

[35] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 156, pl. 3, fig. 4, 1929.

[36] *Idem.*, p. 158, pl. 4, figs. 1*a–d*.

[37] *Idem.*, p. 158, pl. 4, fig. 2, and *Jour. Paleontology*, vol. 5, no. 2, p. 163. 1931.

Upper Pennsylvanian, Wabaunsee group. Howard formation, Loc. 72, 1 specimen; Burlingame limestone, Loc. 71, 5 specimens; Emporia limestone, Loc. 61, 1 specimen. Holotype U. S. Nat. Mus. No. 89479*a*; paratype, No. 89479*b*.

The name is in honor of the late Dr. Sidney Powers.

BAIRDIA GARRISONENSIS Upson
Plate 17, figures 5*a–c*

Bairdia garrisonensis UPSON, *1933*, Nebr. Geol. Survey, Bull. 8, 2d ser., p. 20, pl. 1, figs. 10*a–c;* Garrison formation, Permian; Kansas-Nebraska line.

Carapace large, subrectangular; anterior beak broad and above the mid-height of the valve; posterior beak low and bluntly acuminate; dorsal margin strongly arched; ventral margin very slightly convex; carapace thick in dorsal view; apparent overlap present all around except at the extreme ends of the beaks; dorsal line of contact depressed only along the straight post-dorsal portion.

Measurement of the figured specimen: Length 1.52 mm., height 0.96 mm., width 0.68 mm.

B. garrisonensis lacks the strong inflation of *B. menardensis* Harlton;[38] the posterior beak is much lower and the venter straighter and the hinge contact different from *B. beedei* Ulrich and Bassler (Pl. 14, figs. 1*a–g*).

Pennsylvanian and Permian. Found in outcrop material from the Deer Creek formation upward into the Wreford formation, Permian. Found in deep wells as high as the Ft. Riley and Florence flint. Deer Creek formation, Loc. 18, 1 specimen. Howard formation, Loc. 25, 1 specimen. Burlingame limestone, Loc. 71, 1 specimen. Wakarusa limestone, Loc. 15, 16 specimens. Tarkio limestone, Loc. 32, 2 specimens. Falls City limestone (?) Loc. 40, 1 specimen. Elmdale formation, Loc. 41 A, 1 specimen; Loc. 60, 2 specimens; Loc. 60 X, 3 specimens; Loc. 64, 16 specimens. Cottonwood limestone, Loc. 44, 4 specimens; Loc. 73, 2 specimens. Wreford formation, Loc. 43, 4 specimens; Loc. 47, 1 specimen; Loc. 57, 3 specimens. Plesiotypes, U. S. Nat. Mus. No. 89480.

[38] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 158, pl. 4, figs. 1*a–d*, 1929.

BAIRDIA EISSENSIS (?) Upson
Plate 14, figures 7*a*, *b*

Bairdia eissensis UPSON, *1933*, Nebr. Geol. Survey, Bull. 8, p. 20, pl. 1, figs. 10*a–c;* Eiss limestone, Garrison formation, Permian; Kansas-Nebraska line.

Carapace large; dorsal margin moderately arched; anterior beak very slightly upturned and just above the mid-height of the valve; posterior beak below the mid-height of the valve; carapace in dorsal view moderately thick, lanceolate; dorsal apparent overlap fairly strong.

Measurements of the figured specimen: Length 1.49 mm., height 0.84 mm., width 0.64 mm.

The specimen described above is a little smaller than the type of *B. eissensis* and somewhat shorter, otherwise it quite re-

EXPLANATION OF PLATE 17
All figures ×30

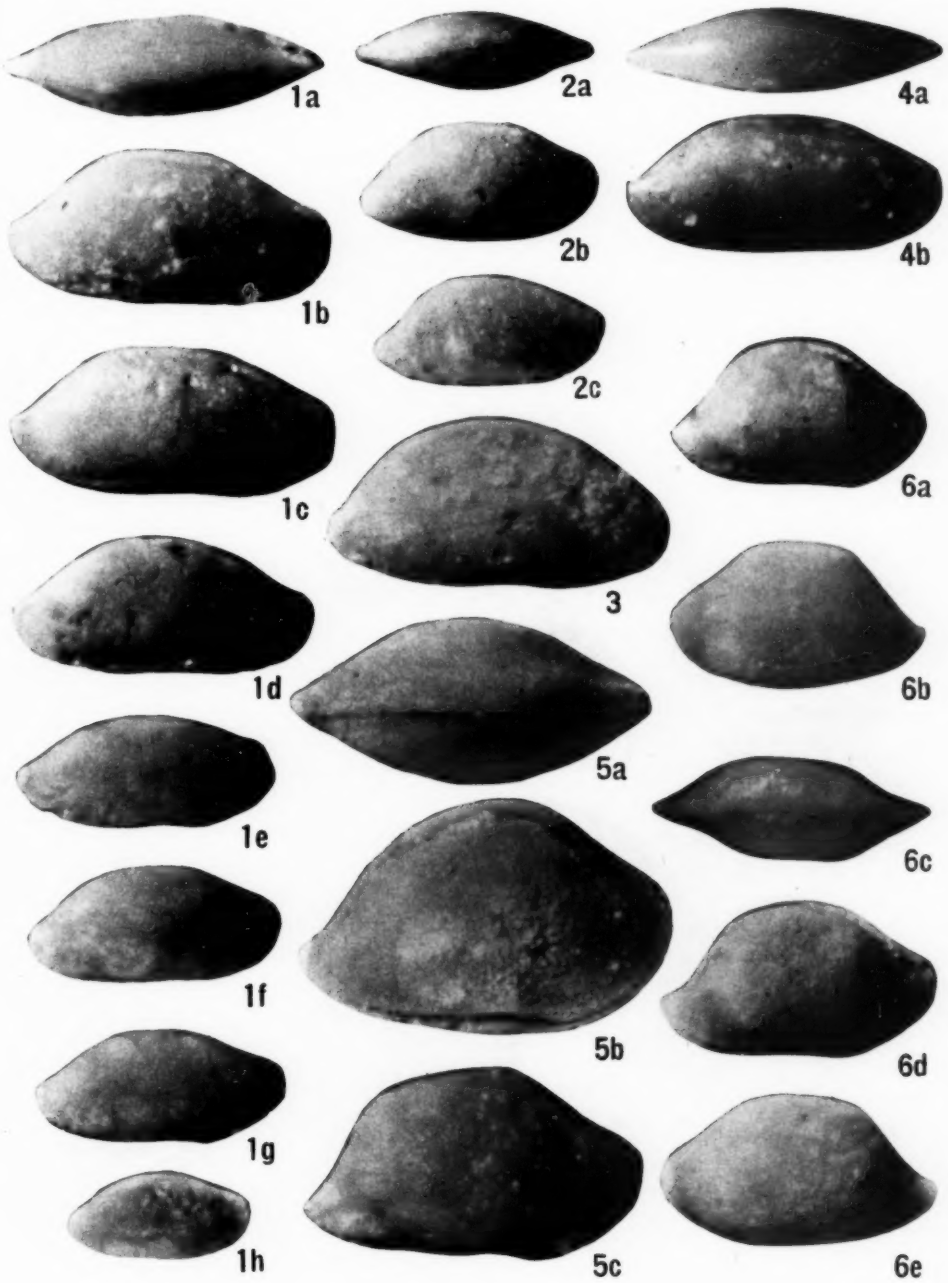
FIGS. 1*a–h*, 4*a–b*—*Bairdia reussiana* Kirkby. 1*a* is the dorsal view of 1*b*, the cyrioplesiotype. 1*c–h* are right views carapaces, Wreford formation, Loc. 47. 4*a*, *b*, dorsal view and right side carapace of a longer specimen from Cottonwood limestone, Loc. 44. (p. 132)

2*a–c*—*Bairdia verwiebei* (?) Kellett, n. sp. 2*a*, *b*, dorsal view and right side carapace. 2*c*, right side carapace. Falls City limestone (?), Loc. 40. (p. 129)

3—*Bairdia hoffmanae* Kellett, n. sp. Right side carapace holotype. Americus limestone, Loc. 70. (p. 133)

5*a–c*—*Bairdia garrisonensis* Upson. 5*a–b*, dorsal view and right side carapace, cyrioplesiotype. 5*c*, right valve. Elmdale formation, Loc. 60. (p. 134)

6*a–e*—*Bairdia powersi* Kellett, n. sp. 6*a–b*, right and left side carapace. 6*c–e*, holotype, dorsal view and right and left sides carapace. Note dorsal ridge on left valves, 6*b* and 6*e*. Burlingame limestone, Loc. 71. (p. 133)



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sembles the figures of *B. eissensis* and is doubtfully referred to that species, the difference in elongation being possibly merely an individual variation.

Plesiotype, U. S. Nat. Mus. No. 89481.

Bairdia ampla group

The following species of *Bairdia* form a convenient group showing few distinctive features and which may be described in general as: carapace short to fairly elongate, of medium thickness; venter almost straight with a slight central concavity; dorsum straight to slightly arched; anterior end broadly and evenly rounded; posterior end short and blunt to slightly acuminate; dorsal apparent overlap long, moderate and fairly even; ventral overlap slight; hinge line slightly impressed posteriorly.

Extreme care must be used in differentiating these species, and they should be used as stratigraphic markers only with great caution. *B. ampla* Reuss[39] from the Upper Permian of Europe was the first to be described. Later Jones and Kirkby referred many different forms, some as varieties, to this species. *B. texana* Harlton,[40] *B. altifrons* Knight,[41] and *B. recta* Harlton[42] may be placed in this group. Plates 18 and 19 of this paper show other species of this group: *B. forakerensis*, n. sp., *B. nevensis*, n. sp., *B. florenaensis* Upson, *B. chasae*, n. sp., and *B. folgeri*, n. sp.

Specimens of the latter three species are abundant and each species may be divided into what appear at first to be two distinct species, the one being shorter, higher, and with a slightly more arched dorsum than the other. However, the few intergrading forms, and the prominent characteristics common to both the long and short variations, such as the inflation seen in the dorsal view *B. folgeri* (compare Pl. 18, figs. 4*a–f*, and Pl. 19, figs. 6*a–d*) soon convince one that the two forms very probably belong to the same species. The higher form is possibly the female and the more elongate the male of the species.

The species from the Early Pennsylvanian identified by Warthin[43] as *B. altifrons* Knight is figured (Pl. 18, figs. 6*a–b*) in order to differentiate similar later Pennsylvanian species. It is much higher than the type figured by Knight, but may possibly be the female of the species. The measurements of the figured specimen are: Length 1.09, mm., height, 0.64 mm., width 0.42 mm. U. S. Nat. Mus. No. 89501.

Bairdia chasae Kellett, n. sp.

Plate 18, figures 5*a–d;* Plate 19, figures 5*a–d*

B. chasae resembles several different forms referred by Jones and Kirkby to *B. ampla* Reuss but it is either thicker or has less attenuated ends than any of these. It is larger, more elongate even in its shortest expression, and slightly less attenuated at the ends than *B. altifrons* (?) Knight (Pl. 18, figs. 6*a*, *b*). The sides of *B. chasae* are more nearly parallel in both lateral and dorsal views than those of *B. folgeri*, n. sp. (Pl. 18, figs. 4*a–f;* Pl. 19, figs. 6*a–d*). *B. chasae* and *B. florenaensis* Upson can scarcely be distinguished in lateral view but in dorsal view *B. chasae* appears much wider and more nearly rectangular.

Measurements of the figured specimens:—

	Length	*Height*	*Width*
Plate 18, figures 5*a*, *b*	1.18 mm.	0.67 mm.	0.50 mm.
5*c*, *d*	1.23 mm.	0.68 mm.	0.49 mm.
Plate 19, figures 5*a*, *b*	1.27 mm.	0.63 mm.	0.47 mm.
5*c*, *d*	1.14 mm.	0.61 mm.	0.44 mm.

[39] Reuss, A. E., *Jahrb. Wett. Ges.* etc., pp. 59–77, pl. fig. 7, 1854.

[40] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 210, pl. 33, fig. 9, 1927.

[41] Knight, J. B., *Jour. Paleontology*, vol. 2, p. 324, pl. 43, figs. 6*a*, *b*, 1928.

[42] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 159, pl. 4, figs. 4*a–e*, 1929.

[43] Warthin, Aldred H., *Okla. Geol. Survey, Bull.* 53, p. 70, pl. 5, figs. 10*a*, *b*, 1930.

Upper Shawnee group, Pennsylvanian. Deer Creek formation, Loc. 17, 4 specimens; Loc. 18, 15 specimens. Topeka formation, Loc. 26, 1 specimen; Loc. 34, 7 specimens. Holotype U. S. Nat. Mus. No. 89482*a*; paratypes No. 89482 *b–d*.

The name is in honor of Mrs. Edmond Chase of the Amerada Petroleum Corporation, Tulsa, Oklahoma.

BAIRDIA FOLGERI Kellett, n. sp.
Plate 18, figures 1*e–f*, 4*a–f*; Plate 19 figures 1*a–d*, 4*a –f*, 6*a–d*

B. folgeri is characterized by the curved and somewhat inflated outline in dorsal view. It very closely resembles *B. florenaensis* Upson in lateral view, see Plates 18 and 19, but in dorsal view it is more inflated and the sides less straight. The dorsum of *B. folgeri* is less sharply arched than that of *B. oklahomaensis* Harlton,[44] and the posterior more acuminate.

The specimens, Plate 19, figures 4*a–f*, are immature molts and have the tapering posteriors characteristic of the young of many species of *Bairdia*.

The adults of this species in both Kansas and Oklahoma appear to attain a distinctly larger size in the Howard formation, see Plate 18, figures 4*a–f*, and Plate 19, figures 6*a–d*, than in the overlying Burlingame and Wakarusa limestones, see Plate 18, figures 1*e–f*, and Plate 19, figures 1*a–d*. The measurements of the figured specimens show this decrease in size in the later strata:—

Specimens from the Howard formation.

	Length	*Height*	*Width*
Plate 18, figures 4*a, b*	1.09 mm.	0.64 mm.	0.51 mm.
4*c, d*	1.11 mm.	0.65 mm.	0.50 mm.
4*e, f*	1.14 mm.	0.69 mm.	0.55 mm.
Plate 19, figures 6*a, b*	1.18 mm.	0.65 mm.	0.49 mm.
6*c, d*	1.18 mm.	0.65 mm.	0.50 mm.

Specimens from the Burlingame and Wakarusa limestones.

Plate 18, figures 1*e, f*	1.03 mm.	0.60 mm.	0.44 mm.
Plate 19, figures 1*a, b*	1.01 mm.	0.56 mm.	0.41 mm.
1*c, d*	1.00 mm.	0.52 mm.	0.37 mm.

EXPLANATION OF PLATE 18

All figures ×30

Right sides of carapaces with the dorsal view above each

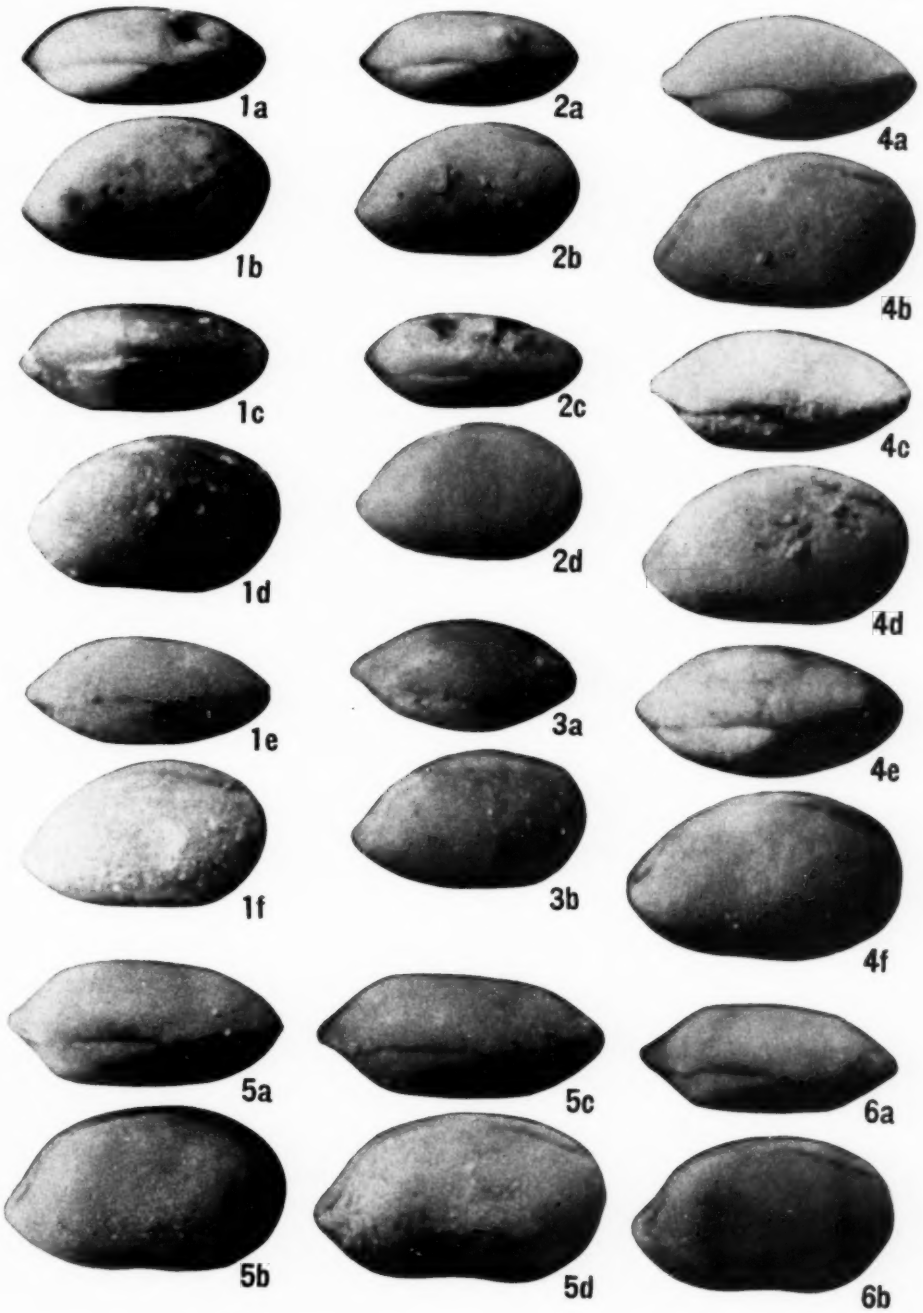
FIGS. 1*a–d*, 2*a–d*—*Bairdia florenaensis* Upson, short forms. 1*a–b*, Elmdale formation, Loc. 65. 1*c–d*, Cottonwood limestone or Florena shale, Loc. 73. 2*a–d*, Wreford formation, Loc. 57. Note that the Wreford forms figured, which are quite characteristic of some localities in that formation, are smaller than those found in the lower strata. (p. 137)

1*e–f*, 4*a–f*—*Bairdia folgeri* Kellett, n. sp., short forms. 4*a–f* from the Howard formation, Loc. 25. 1*e–f* from the Wakarusa limestone, Loc. 15. Holotype, 4*e–f*, paratypes, 1*e–f*, 4*a–d*. Note the inflation of *B. folgeri* in dorsal view as compared with *B. florenaensis*. (p. 136)

3*a–b*—*Bairdia forakerensis* Kellett, n. sp. Holotype, Elmdale formation, Loc. 60 X. (p. 137)

5*a–d*—*Bairdia chasae* Kellett, n. sp., short forms. Deer Creek formation, Loc. 18. Holotype 5*a–b*, paratype 5*c–d*. (p. 135)

6*a–b*—*Bairdia altifrons* (?) Knight. This species was figured by Warthin as *B. altifrons* Knight. It is much higher than the holotype but may be the female of *B. altifrons*. Wewoka formation, Morgan and Fitts' locality, 1,300 feet N. of the SW. ¼ of sec. 4, T. 7 E., R. 3 N., Oklahoma. (p. 135)



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Pennsylvanian, lower Wabaunsee group. Howard formation, Loc. 25, 53 specimens; Loc. 72, (Howard?) 2 specimens; Bird Creek limestone, an equivalent of the Howard, Stop 11 of the Okla. Geol. Soc. field trip, 1930, center sec. 16, T. 27 N., R. 8 E., Oklahoma, 4 specimens. Burlingame limestone, Loc. 71, 22 specimens; Loc. 16, 1 specimen; and in the "Cryptozoan limestone" of Oklahoma of the same age, center NE. ¼ sec. 1, T.26 N., R.2 E., 4 specimens. Wakarusa limestone, Loc. 15, 6 specimens. Holotype, U. S. Nat. Mus. No. 89483*a*, paratypes, Nos. 89483*b–f*.

The name is in honor of Mr. Anthony Folger of the Gypsy Oil Company, Wichita, Kansas.

BAIRDIA FORAKERENSIS Kellett, n. sp.
Plate 18, figures 3*a*, *b*

B. forakerensis is characterized by the small, short, inflated carapace with a very broadly rounded anterior margin in lateral view which is straighter than that of either *B. florenaensis* n. sp. (Pl 18, figs. 1*a–d*, 2*a–d*) or of *B. folgeri*, (Pl. 18, figs. 4*a–f*).

Measurements of the holotype: Length 0.98, height 0.57, width 0.46.

Found only in the lowermost Permian Elmdale formation of Kansas and the correlative Foraker formation of Oklahoma. Elmdale formation, Loc. 41A, 2 specimens, Loc. 60 X, 2 specimens. Basal Foraker, Stop. 4 of the Oklahoma City Geological Society field trip in the fall of 1930, SE. ¼ sec. 35, T. 26 N., R. 7 E., Oklahoma. Holotype U. S. Nat. Mus. No. 89484.

[44] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 209, pl. 33, fig. 7, 1927; *Texas, Univ. Bull.*, 2901, p. 156, pl. 3, figs. 5*a*, *b*, 1929.
[45] *Idem.*

BAIRDIA NEVENSIS Kellett, n. sp.
Plate 19, figures 3*a*, *b*

Carapace large, elongate, and thick; sides straight and parallel; anterior in dorsal view blunt. *B. nevensis* is nearest the large new species *B. chasae* (Pl. 19, figs. 5*a–b*) but the ends are less attenuated in both side and dorsal views, especially the latter, and the posterior beak is slightly higher. Measurements of the holotype: Length 1.31 mm., height 0.67 mm., width 0.40 mm.

Lower Permian, Neva formation, Loc. 67, 2 specimens. Holotype, U. S. Nat. Mus. No. 89485.

BAIRDIA FLORENAENSIS Upson
Plate 18, figures 1*a–d*, 2*a–d*;
Plate 19, figures 1*e*–2*d*;
Plate 14, figure 4

Bairdia florenaensis UPSON, *1933*, Nebr. Geol. Survey, Bull. 8, 2d ser., p. 22, pl. 2, figs. 4*a*, *b*; Florena shale, Garrison formation, Permian, Nebraska; and Santa Anna Branch shale, upper Cisco, Texas.

This species may be conspecific with the Permian species *B. ampla* Reuss, but the posterior beak is more pointed and the anterior beak less pointed than shown in the type figure of *B. ampla* drawn by Reuss. The short (female?) form of *B. florenaensis* has a lower and more pointed beak than *B. recta* Harlton in which species the posterior beak is at the mid-height of the valve instead of below as in *B. florenaensis*. It is less inflated, and in lateral view more rounded anteriorly than *B. forakerensis* Kellett, n. sp. (Pl. 18, figs. 3*a–b*). It is less angled dorsally than *B. oklahomaensis* Harlton,[45] more broadly rounded anteriorly, and less oblique or truncated in the antero-ventral part.

Measurements of the figured specimens:

	Length	*Height*	*Width*
Plate 18, figures 1*a*, *b*	1.05 mm.	0.59 mm.	0.39 mm.
1*c*, *d*	1.06 mm.	0.64 mm.	0.43 mm.
2*a*, *b*	0.94 mm.	0.55 mm.	0.39 mm.
2*c*, *d*	0.94 mm.	0.57 mm.	0.38 mm.
Plate 19, figures 1*e*, *f*	0.97 mm.	0.53 mm.	0.37 mm.
2*a*, *b*	0.97 mm.	0.52 mm.	0.39 mm.
2*c*, *d*	1.06 mm.	0.53 mm.	0.38 mm.

The above figured specimens are all distinctly smaller than the type of *B. florenaensis* Upson which has a length of 1.21 mm. These small forms, apparently adult molts, are found in quantities at some horizons. Large specimens conforming in size to the type of *B. florenaensis* are also found in samples with the smaller forms, but they are only about one-fifth as abundant as the dwarfed forms. Both the large and the small forms have the same variations in height and appear identical in all characteristics excepting size. In fact it seems impossible to differentiate the so-called dwarfed forms and slightly immature molts of the typical *B. florenaensis*. Although these two forms are here placed in one species for the present, perhaps they are not conspecific.

Of the small forms those from two localities in the Wreford formation are all smaller than those in the lower horizons (see Pl. 18, figs. 2*a–d*, Pl. 19, figs. 2*a–d*). However at other localities in the Wreford they are of the average size for the dwarfed forms. Plesiotypes U. S. Nat. Mus. Nos. 89486 (Loc. 64, unfigured), 89495 (Loc. 50, unfigured), 89496 (Loc. 65), 89497 (Loc. 44), 89498 (Loc. 57), 89499 (Loc. 61), and 89500 (Loc. 73).

Uppermost Pennsylvanian and Permian. Falls City (?) limestone to the Wreford formation, and very rarely found in the lower Ft. Riley limestone. Falls City (?) limestone, Loc. 40, 18 small and 2 large specimens. Americus limestone, Loc. 70, 5 small specimens. Elmdale formation, Loc. 60, 1 small and 4 large specimens; Loc. 60 X, 7 small specimens; Loc. 61, 10 small and 3 large specimens; Loc. 64, 23 small and 7 large specimens; Loc. 65, 15 small specimens and 1 large; Loc. 41, 1 small specimen; Loc. 41 A, 4 small specimens. Neva limestone, Loc. 42, 1 small specimen; Loc. 66, 3 small specimens; Loc. 67, 5 small specimens. Cottonwood limestone; Loc. 73, 7 small specimens and 1 large one; Loc. 44, 50 small and 1 large specimen. Wreford formation, Loc. 68, 3 small and 14 large specimens; Loc. 47, 15 small specimens; Loc. 43, 15 small and 10 large specimens; Loc. 57, 31 large specimens. Lower Ft. Riley limestone, 1 small specimen.

EXPLANATION OF PLATE 19

All figures ×30

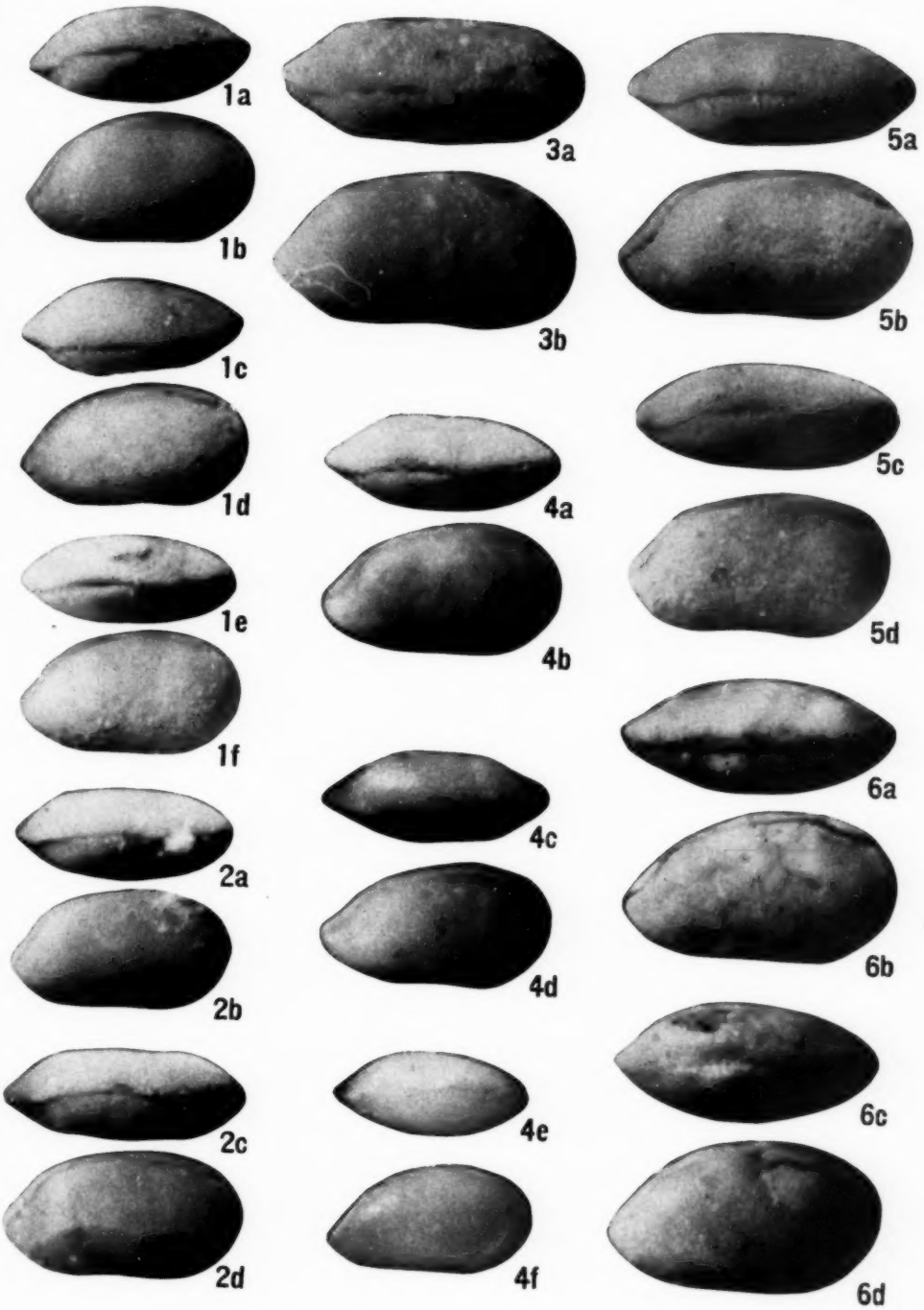
Right sides of carapaces with the dorsal view above each

FIGS. 1*a–d*, 4*a–f*, 6*a–d*—*Bairdia folgeri* Kellett, n. sp. 1*a–d* and 4*c–f* from the Burlingame limestone, Loc. 71. 4*a–b*, 6*a–d* from the Howard formation, Loc. 25. 1*a–b* and 6*a–d* elongate adults, probably males, paratypes. 4*a–f* young specimens; note the tapering posteriors in lateral view which are characteristic of the young of most of the species of *Bairdia* studied. (p. 136)

1*e–f*, 2*a–d*—*Bairdia florenaensis* Upson, elongate forms. 1*e–f*, Wreford formation, Loc. 57. 2*a–d*, Elmdale formation, Loc. 61. (p. 137)

3*a–b*—*Bairdia nevensis* Kellett, n. sp. Holotype, Neva formation, Loc. 67. (p. 137)

5*a–d*—*Bairdia chasae* Kellett, n. sp. Elongate forms, paratypes. Deer Creek formation, Loc. 18. (p. 138)



Kellett, Pennsylvanian and Permian ostracodes

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THE GASTROPODS OF THE ST. LOUIS, MISSOURI, PENNSYLVANIAN OUTLIER: VII. THE EUOMPHALIDAE AND PLATYCERATIDAE

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ABSTRACT

This paper treats of Carboniferous genera of the Euomphalidae and Platyceratidae in general and with American Pennsylvanian species in particular. In respect to the latter the scope has been broadened to include forms not known to occur in the horizons represented in the St. Louis outlier.

The Carboniferous genera of the Euomphalidae are discussed. The writer is inclined to agree with those authors who consider *Euomphalus* Sowerby, *Schizostoma* Brown, and *Phymatifer* de Koninck to be synonyms of *Straparollus* Montfort, though *Euomphalus* is retained as a subgenus. Certain morphological characters in connection with the evanescent apertural sinus of the Carboniferous euomphalids are discussed. It is suggested that some of the species described may have considerable value as guide fossils. A key to the American Pennsylvanian species is presented.

The family name Platyceratidae Hall is adopted for certain Paleozoic genera commonly referred to the Capulidae. The Platyceratidae are considered as Aspidobranchia adapted to a stationary, often pseudoparistic, habit. In the Platyceratidae are placed *Platyceras* Conrad, *Orthonychia* Hall, *Diaphorostoma* Fisher, and *Helictostylus* Knight. The last is a new genus proposed for the reception of those forms commonly placed in *Strophostylus* Hall but left nameless through the recent discovery of their incompatibility with the genotype. Each of these genera is studied and redefined. The nucleus of a species of *Orthonychia* is described for the first time.

The following American species are described and figured: *Straparollus* (*Straparollus*) *savagei* Knight, n. sp., *S.* (*Euomphalus*) *umbilicatus* Meek and Worthen, *S.* (*Euomphalus*) *plummeri* Knight, n. sp., *S.* (*E.*) *serratus* Knight, n. sp., *S.* (*E.*) *hollingsworthi* Knight, n. sp., *S.* (*Euomphalus*) *catilloides* (Conrad), *S.* (*Euomphalus*) *subrugosa* Meek and Worthen, *S.* (*Euomphalus*) *reedsi* Knight, n. sp., *S.* (*Euomphalus*) *muricatus* Knight, n. sp., *S.* (*Euomphalus*) *subsulcatus* Knight, n. sp., *S.* (*Euomphalus*) *subquadratus* Meek and Worthen, *Orthonychia parva* (Swallow), *Helictostylus girtyi* Newell mss., n. sp.

This is the seventh of a series of papers dealing with Pennsylvanian gastropods, chiefly those from the Pennsylvanian outlier at St. Louis (1). As with the preceding paper of the series on the Neritidae (1f), American Pennsylvanian species from other localities than the St. Louis, Pennsylvanian outlier and from other stratigraphic horizons are dealt with. Dr. Norman D. Newell of Yale University and the Kansas Geological Survey has generously put at my disposal the gastropods in his collections that are pertinent to this paper. The collections of the Peabody Museum of Natural History at Yale have also been available to me through the kindness of Prof. C. O. Dunbar. Without these the scope of the paper would have been greatly restricted. I am again indebted to Prof. T. E. Savage of the University of Illinois and Dr. Chester A. Reeds of the American Museum of Natural History for the generous loan of

types, without which the accurate determination of some of the species would have been impossible.

While no pretense is made that this brief study is a finished monograph on American Pennsylvanian Euomphalidae and Platyceratidae, a beginning is made in the consideration of the genera and species in their broader aspects. It begins to appear that some of the forms heretofore thought to range throughout the Pennsylvanian may prove to be more restricted in their stratigraphic range and, therefore, to be good guide fossils. Thus it seems possible, for example, to recognize in the group of forms commonly associated under the name *Schizostoma catilloides*, at least four species (or varieties, if the reader prefers) of which one, *Straparollus* (*Euomphalus*) *reedsi*, n. sp., seems to be limited to the Des Moines series, another *S.* (*E.*) *catilloides* Conrad to the Missouri series, and still another, *S.* (*E.*) *muricatus*, n. sp. to the lower, marine Permian. The fourth, *S.* (*E.*) *subrugosus* Meek and Worthen, is most abundant in the Virgil series though it seems to occur locally lower in the section. Again let it be emphasized that these are preliminary, tentative conclusions only, based on collections that are inadequate, but still probably more representative than any that have been studied heretofore. More extensive collections from a greater geographic and stratigraphic range will be needed to determine these and similar questions with certainty.

A full register of the collecting localities in the St. Louis outlier may be found in a recent paper in the American Journal of Science (2, pp. 175–178), where the stratigraphy is also discussed. For collections made in other areas, the fullest details available are supplied with each citation.

The illustrated specimens (except those that are announced as borrowed or as the property of other institutions) are deposited in the collections of the Peabody Museum of Natural History at Yale University. Unfigured types, in so far as they are available, will be deposited in the United States National Museum in Washington, at Washington University in St. Louis, and at the Musée Royale d' Histoire Naturelle in Bruxelles, Belgium.

Acknowledgement is made to the Sterling Fund of Yale University for assistance in the preparation of this paper.

Family EUOMPHALIDAE de Koninck, 1881

Widely phaneromphalous gastropods, usually subdiscoidal but in some cases subtrochiform in shape, and with a tendency to develop a sinus in the upper half of the outer lip; shell distinctly of two layers, the outer layer seemingly calcareous and often retaining traces of pigmentation, the inner one possibly nacreous; earlier whorls partitioned off by transverse septa as they were abandoned; nucleus simple, dextral and flatly coiled; operculum unknown and presumably not calcareous.

The tendency to develop a sinus is very marked in some of the older

Paleozoic genera but in the Carboniferous genera, with which we are now particularly concerned, it finds so little expression that a reentrant sinus is almost if not quite obsolete. Thus, in the well known Mississippian species *Euomphalus pentangulatus* Sowerby the sinus only finds expression at ephebic stages in a slightly keeled but angular shoulder. At nepionic and neanic stages even this is lacking. In *Straparollus dionysii* Montfort the rounded whorls seen in the neanic stages of *E. pentangulatus* seem to persist throughout life, though there is, even in this species, an obscure suggestion of shouldering and a very slight insinuation on the later whorls.

Ulrich and Scofield (3, p. 1027), in discussing the characters of Carboniferous euomphalids, describe what appeared to be a sinus *in the inner shell layers* over the upper angulation of an exfoliated specimen of an unnamed euomphalid from the Pennsylvanian at Kansas City, Missouri. There can be little doubt that the species is *Straparollus* (*Euomphalus*) *plummeri* described herein since it occurs in the horizon exposed at Kansas City and is comparable to *E. planidorsatus* (Meek and Worthen) used for comparison by Ulrich and Scofield. I do not have a specimen that shows the interesting feature described by Ulrich and Scofield, but I have studied the apertures and sections of a number of Carboniferous species and have noted certain characters that seem to demonstrate what might be called a *potential* if not actual sinus at the upper angulation of Carboniferous euomphalids. Indeed, an angulation itself forms a sort of sinus in that the edges of the shell meet at its apex at a more or less rounded angle and, if the angulation is an elevated carina, at an acute angle. The difference between this type of sinus and the more usual type is merely a difference in the plane in which the edges of the sinus lie. Each type may function as a channel or passageway for the protrusion of an organ, such as an anal tube, and thus be morphologically homologous.

In the group of *Euomphalus catilloides* there are two carinate angulations and it seems significant that the structure of the upper one shows that it was the seat of a shallow channel, while no such channel existed in the otherwise quite similar lower carina.[1]

Thin, or polished, sections of specimens of *S.* (*E.*) *plummeri*, and of five species of the group of *S.* (*E.*) *catilloides* have been studied. Photographs of these are shown on Plate 26, although it has not been possible to reproduce in the photographs all the details that may be seen in the sections under a microscope. The outer shell layer of each is prismatic and, as suggested by its commonly excellent preservation, the prisms were of calcite. The prisms are orientated normal to the outer surface of the shell and to the inner surface. At all points in a given section, except in the upper carina, the prisms pass almost directly through the

[1] Throughout this paper the Carboniferous euomphalids treated are considered as dextral, a point that hardly needs to be argued.

shell from one surface to the other. In the upper carina many of the prisms pass inward from the outer shell surface toward the median plane of the carina and bend sharply close to the median plane (a line, in the section), and follow it closely to the inner surface of the shell. The median plane must mark the position of a fold of the mantle occupying a shallow channel in the upper carina. Since the fold was maintained only near the aperture and since it moved forward with the growth of the shell, the channel became rapidly shallower at any given point and was completely filled with prismatic shell material before the deposition of any of the lamellar inner shell layers by the surface of the mantle back from the aperture. Figures 8*a*, *b* on Plate 24 shows this channel in the aperture of a specimen of *S.* (*E.*) *reedsi*.

It is obvious that if the outer shell layer were partly exfoliated to a plane roughly paralleling the surface, as in Ulrich's specimen mentioned above, the successive increments of shell material would form contour lines of successive positions of the channel in the angulation as it advanced forward the growth, and that these contour lines would appear in any plane beneath the surface, but roughly parallel to it, as marks of a re-entrant sinus in that plane. In some species a slight sinus of the more typical, re-entrant type is combined with the channelling of the upper angulation.

Ulrich's view that the Euomphalidae are an offshoot of the same early type that gave rise to the Raphistomatidae and Pleurotomariidae (3, p. 1023) seems reasonable. That the Euomphalidae are in any way ancestral to the Tertiary and Recent Architectonicidae, as maintained by some authors, seems extremely doubtful to say the least.

The Genera.—It would carry this study too far afield to pass in review the many genera of the earlier Paleozoic systems that seem properly to find a place in the Euomphalidae, though it may not be amiss to say in passing that *Maclurites* and its closer relatives should be excluded, since the omission of these forms leaves the family a much more compact unit. That group of Permian species referred by Girty and others to *Omphalotrochus* Meek seemingly finds a place in the Euomphalidae, though I am not prepared to accept them as true representatives of Meek's genus. *Omphalotrochus* Meek, genotype *O. whitneyi*, seems more properly placed in the Trocho-turbinidae.

We find in the literature a number of generic names based on Carboniferous genotypes and abundantly represented in the later Paleozoic rocks. These are *Straparollus* Montfort, *Euomphalus* Sowerby, *Schizostoma* Bronn, *Phymatifer* de Koninck, and *Phanerotinus* Sowerby. We will here be concerned principally with the first three.

Straparollus Montfort, 1810 (4, p. 174), has for its genotype (original designation) *S. dionysii* Montfort, a species which, if not certainly recognizable from among closely related forms, is, as far as its general char-

acters are concerned, well known. On Plate 20, figure 1 a photograph of *S. dionysii*, or a *very closely related* species, is reproduced. The form is a low cone, the summit of which is somewhat flattened, the umbilicus is wide and deep and the whorls, though rounded, show a very slight tendency to shouldering on their upper half. The growth lines pass downward over the whorls with a slight obliquity and with hardly a trace of sinus. Neither Montfort's nor de Koninck's figures of *S. dionysii* show a flattened apex but de Koninck mentions it particularly in the text of his description. Both Montfort's and de Koninck's illustrations are notoriously inaccurate in details.

Euomphalus Sowerby, 1812, has for its type, by subsequent designation (5a, p. 158), *E. pentangulatus* Sowerby, 1812.

Schizostoma Bronn, 1835, has for its type *Euomphalus catillus* Sowerby, 1812.[2] Copies of Sowerby's original figures of *E. pentangulatus* and *E. catillus* (6, pl. 45) are reproduced on Plate 20. It will be noted that there is only one difference between the two shells that seems to be of any importance; the outer margin of the base of *E. catillus* is sharply angulated as against a more smoothly rounded base in the mature stages of *E. pentangulatus*. Yet the difference is only one of degree, for in the latter at early ephebic stages the whorl base is rounded so sharply as to be almost angular too. *Euomphalus pentangulatus* is a *Schizostoma*, so to speak, until late ephebic stages of growth, when the lower angulation rounds out.

I have before me several collections of *E. pentangulatus* from Ireland, England and Belgium totaling nearly forty excellent specimens. In this collection, what seems to be individual variation in angulation of the base, accompanied by an inward slope of the upper, flattened whorl surface, seems to cover almost completely the range of differences between *E. pentangulatus* and *E. catillus*. I do not maintain that the two genotypes are conspecific (though it is possible that they are), but it seems obvious that the names *Euomphalus* and *Schizostoma* are subjective, if not exact, synonyms. This conclusion has been reached before by various authors with various shades of emphasis; indeed *Schizostoma* is today recognized by but few as an independent genus.

Some authors go so far as to consider *Euomphalus*, *Schizostoma* and *Phymatifer*, all three, as subjective synonyms of *Straparollus*, and when one reviews a large suite of Carboniferous species of the genera, so complete an integration is found in the characters that are supposed to distinguish them that the suggestion appears to have much merit.

There seems to be latent in the species of the later Paleozoic Euomphalidae certain unit characters that may find expression independently and at different times, in different

[2] This species was first described by Martin as *Conchyliolithus Helicites catillus* in 1808 but Martin's name is not Linnean and hence I cite it from Sowerby who was the first to use it as a binomial.

and not immediately related species. These characters may be summarized as follows:

A. Relatively high spire.
B. Relatively depressed spire
C. Rounded or only slightly shouldered whorls.
D. Angulate to carinate shoulder on upper surface.
E. Angulate to carinate shoulder on lower surface.
F. A row of nodes at the angulation of the upper shoulder.
G. A row of nodes at the angulation of the lower shoulder.

While almost any combinations of two or three of these unit characters that are not mutually exclusive may often be seen in a large collection of euomphalid species, there seems to be a tendency for *A* and *C* to correlate, to occur together, and hence it may be expedient to set such species aside from the others, grouped around *Straparollus dionysii*, as a subgenus, *Straparollus* (ss). The other characters commonly occur in various combinations on relatively low-spired forms with at least an angulate upper whorl shoulder. These forms, grouped about *Euomphalus pentangulatus*, seem to form another subgeneric group *Euomphalus*. I can see no reason, either on practical or theoretical grounds, to regard the names *Schizostoma* and *Phymatifer* as other than synonyms of *Euomphalus*. Indeed it is difficult enough in practice to distribute even into the two subgenera *Straparollus* and *Euomphalus* here recognized the numerous species illustrated by de Koninck (7), or found in any extensive collection. Yet the greatest number of species may be placed with considerable facility in one or the other subgenus and there is the further stratigraphic incentive to maintain the division in that *Straparollus* (ss) seems to drop out after the lowermost Pennsylvanian, allowing *Euomphalus* to carry on alone.

Species corresponding in form to *Straparollus* (ss) and *Euomphalus*, as well as schizostomatid and phymatiferid species, occur throughout the Upper Paleozoic from Devonian times onward, and the schizostomatid type is represented even earlier in species such as *E. walmstedti* Lindström from the Silurian of Gotland. Chronogenesis seems to suggest that the schizostomatid type is the more primitive. The ontogeny of such species as *E. pentangulatus* tends to confirm the suggestion, since each individual passes through schizostomatid neanic and early ephebic stages. The nucleus itself has simple rounded whorls, but this does not necessarily point to an earlier straparollid stage since simple rounded whorls are characteristic of almost any nepionic gastropod. Tentatively I am inclined to look at the evolution of the Euomphalidae, from the Silurian on, as the reflection of several tendencies which seem to find expression repeatedly in different combinations. The first of these is to suppress the lower angulation at late ephebic stages thus producing the euomphalid type, to suppress both the upper and lower angulations giving rise to the straparollid type, and to uncoil to produce the phanerotinid type, or to stress the rugosities

on either or both angulations to produce the phymateferid type. I can see no evidence that the forms expressing these characters occur in phyletic series. The intergradation between the different types seem too complete throughout the whole of the later Paleozoic. The tendencies never seemed to harden into cleavable, phyletic units, carrying over any great length of time, except in the case of *Straparollus* and *Euomphalus* themselves. It seems as though evolution was continually beginning anew.

Euomphalus, in its most typical expression, is well represented in the American Pennsylvanian, but by a few species only. The almost discoidal forms with sharp, often elevated and rugose carinae at both the upper and lower peripheral margins, that is to say exaggerated schizostomatid forms, are more numerous in species and often overwhelmingly abundant as individuals. It is thought that with careful discrimination they may be used as valuable index fossils. Though there seem to be valid reasons why the term *Schizostoma* may not be applied to them, they form when viewed in the narrower field of the American Pennsylvanian a group apart that will here be designated the group of *Euomphalus catilloides*.

Included in the group of *Euomphalus catilloides* are the following species described or redescribed in this paper:

Straparollus (*Euomphalus*) *catilloides* Conrad

S. (*E.*) *subrugosus* Meek and Worthen

S. (*E.*) *subquadratus* Meek and Worthen

S. (*E.*) *subsulcatus* Knight, n. sp.

S. (*E.*) *reedsi* Knight, n. sp.

S. (*E.*) *muricatus* Knight, n. sp.

S. (*E.*) *hollingsworthi* Knight, n. sp.

What may be called the group of *Euomphalus pentangulatus* will include:

S. (*E.*) *pernodosus* Meek and Worthen, a phymatiferid species not described here.

S. (*E.*) *umbilicatus* Meek and Worthen

S. (*E.*) *plummeri* Knight, n. sp.

S. (*E.*) *serratus* Knight, n. sp., a phymatiferid species.

In *Staparollus* (s.s.) is placed, not without some hesitation:

S. (*S.*) *savagei* Knight, n. sp.

Of the above, only two, *S.* (*E.*) *reedsi* and *S.* (*E.*) *umbilicatus*, have been found in the St. Louis outlier.

Family PLATYCERATIDAE Hall, 1859[3]

Naticiform to capulid-like gastropods, commonly with the whorls more or less uncoiled; shell thin and seemingly without a nacreous layer but with a thin secondary layer within; frequently irregular in growth; ornamentation either simple growth-lines, transverse or longitudinal lirae, or both; shell and ornamentation both with a strong tendency to irregularity; some forms with long, hollow spines. In a very few specimens what may be muscle scars

[3] Hall used the name Platyceridae in 1859 as a caption to Plates 1 to 8 of volume 5, part 2, of the Palaeontology of New York but in the text he does not mention this or any other family placement for *Platyceras* and allied genera. Nevertheless since the family termination was employed on the plates it seems proper to cite the name from Hall who was seemingly the first to use it. His rendition of the name must be corrected as above.

have been described. These are in the form of two oval areas on the sides, connected across the posterior by a narrow band.

The more or less pronounced irregularities of growth that characterize the family are to be attributed to a stationary habit of life, the irregularities of the substratum having a marked effect on the shell. Many species are known to have lived attached to crinoids in such a position as to have derived nourishment from the ejecta of their host. Others may have chosen other stations and may have fed on microscopic necton as do their living homeomorphs in several diverse orders or suborders of gastropods today.

There seems to be no valid reason to include the Paleozoic platyceratids in the Capulidae, the resemblance between *Capulus* and *Platyceras* being superficial homeomorphy. There is practically no resemblance between the other genera of either family. Though the evidence is slight, it seems reasonable to regard the Platyceratidae as Aspidobranchia adapted to a stationary habit. Their derivation may well have been from some trocho-turbinid ancestor of active habit such as *Holopea* Hall. One reason for regarding the Platyceratidae as Aspidobranchia has to do with an indefinable something about their shell structure that in common with a similar character in the outer shell layers of the Pleurotomariidae, the Trochɔ-turbinidae, the Neritidae and the Euomphalidae, seems to give these layers a superior resistance to corrosion or to recrystallization rarely met with in the Paleozoic species of other orders. The outer shell layers were probably strongly calcitic.

In spite of superficial resemblance between examples of *Diaphorostoma* in the Platyceratidae and *Naticopsis* in the Neritidae, there seems to be no reasonable ground to associate the Platyceratidae genetically with the Neritidae as is done by some authors, though both were probably derived from a primitive, *Holopea*-like trochoturbinid. The Neritidae are normal, free-living Aspidobranchia, characterized by the loss of the pearly character of the inner shell-layer, by the thickening of the columellar lip in the plain of the aperture, and by a calcareous layer on the operculum. That they were derived from any genus of the Platyceratidae, specialized as are the latter for a stationary habit, most probably without an operculum of any sort and commonly without a columella, seems highly improbable.

In the Platyceratidae I would place the genera *Platyceras* Conrad, *Orthonychia* Hall, *Diaphorostoma* Fisher, and the genus that has long been known erroneously under the name *Strophostylus* Hall for which the name *Helictostylus* is here proposed. *Palaeocapulus* Grabau and Shimer may have a place in it either as an independent genus or, more probably, as a synonym of *Orthonychia*. Among those Paleozoic genera that are commonly included with the platyceratids in the Capulidae, I would exclude from either family *Stenotheca* Salter, *Helcionella* Grabau

and Shimer, *Naticonema* Perner, *Cirropsis* Perner, *Pollicina* Koken, and others that are so different from the platyceratids and capulids as not to merit specific mention. The genus *Exogyroceras* Meek and Worthen may belong here but it seems very doubtful.

Platyceras.—The genus *Platyceras* was erected by Conrad in 1840 (8, p. 205), and Miller in 1889 (9, p. 415) designated *P. dumosum* Conrad as genotype. The characters of the genus are those given above for the Platyceratidae except that the genus *Platyceras* is limited to forms with the earlier whorls coiled and in contact, but with the last whorl free. The genotype is ornamentated by large conspicuous spines, though this is not here held to be of generic importance. Should the development of spines be considered to set the genotype and such other species as have the same characters apart from forms similar in all respects but lacking spines, the genus *Acrocylia* Phillips, 1841 (10, p. 93), genotype *Pileopsis vetusta* Sowerby, here designated, commonly regarded as a subjective synonym of *Platyceras*, is available for the spineless forms. The name *Actita* Fisher de Waldheim may possibly have priority over both *Platyceras* and *Acrocylia*, though from evidence at hand it seems not to have been validly established until 1844. The name was first used by Fisher de Waldheim in 1823 (11, p. 234), but without diagnosis, indication, illustration or any species being referred to it. Hence, as of its original proposal, it was a *nomen nudum* with no standing in nomenclature. As far as I have been able to learn it remained a *nomen nudum* until 1844 when it was used for a species of *Platyceras*, *Actita munsteriana* Fisher de Waldheim (12, p. 802), which automatically became the genotype and established the name as a synonym of *Platyceras* or, more closely, of *Acrocylia*.

Orthonychia.—The name *Orthonychia* was first proposed by Hall without being coupled with a specific name in 1843 (13, p. 172, fig. 3) to designate a specimen of what Hall described in 1859 as *Platyceras subrectum* (not *P. subrectum* Hall 1860= *P. infundibulum* Meek and Worthen 1866) though by the time a specific name was proposed Hall had abandoned the genus. *P. subrectum* was made nomenclatorially available as genotype by virtue of being among the first species to be referred by name to the genus (14, p. 1) and was formally designated as such in 1915 (15, p. 923).

The characters of *Orthonychia* are those given above for the family except that the genus is composed of species with no part of the shell closely coiled. The form of the shell generally shows some degree of spiral twist, and often an arcuate curvature, but there is no true coiling, even in the nucleus, if my specimens referred to the genus are typical in this respect. As far as I am aware, I am able to show the characters of the nucleus of *Orthonychia* for the first time, since the fragile tip of the shell is rarely preserved. Unfortunately the nucleus is not known in the

genotype species but it seems safe to infer that it is similar to that described for *Orthonychia parva* (Swallow) in the following pages (see Pl. 25, fig. 1 *d–g*).

Orthonychia was abandonded by Hall and many authors today do not feel that it is distinct from *Platyceras*. Yet the hooklike nucleus in the former as compared with the coiled earlier whorls of *Platyceras* seems so to strengthen the separation of the two that the distinction must be recognized, though it may be difficult to apply to fragmentary specimens.

The name *Igoceras* seems to have been proposed first by Hall provisionally in 1859 (16, p. 330), but he mentions it in the past tense as though he had used it earlier. I have been unable to find an earlier reference. Hall gives a definition of the provisional genus but does not adopt the name or use it in connection with any species. Apparently the first species to be referred to the genus (and, therfore, the genotype) was *Platyceras plicata* (Conrad) cited by Meek and Worthen in 1866 as an example of the genus. However it seems impossible to recognize *Igoceras* as generically distinct from *Orthonychia*, and it will here be considered a synonym.

Diaphorostoma.—The name *Diaphorostoma* was proposed by Fisher with diagnosis in 1885 (1887?) seemingly to replace *Platy(o)stoma* Conrad 1842, preoccupied, though he is not specific on this point (17, p. 756). A single species is mentioned and figured, *Diaphorostoma niagarense* (Hall), a species that would be included in *Platyceras* as here used. However, he cites in the synonymy of his new genus "*Platyostoma* (Conrad 1842, non *Platystoma*, Klein, 1753, *nec* Meigen, 1803, *nec* Agassiz, 1829, *nec* Laube, 1855, etc.)." Thus, by compulsory inference, the genotype of *Platystoma* Conrad, *P. ventricosum* Conrad, is also included by Fisher in his new genus, and was available when Bassler designated it genotype of *Diaphorostoma* in 1915 (15, p. 406). *Diaphorostoma* Fisher is thus an exact synonym of *Platystoma* Conrad suppressed as an homonym. There can be no question that Conrad's original rendering of the name as *Platyostoma* was a *lapsus* and that the correction to *Platystoma* was entirely in order.

The characters of *Diaphorostoma* are those of the family, except that the whorls are coiled and in contact throughout, and there is a columella which is simple and without a revolving fold. It is very doubtful whether *Diaphorostoma* can stand as generically distinct from *Platyceras*.

Helictostylus.—In 1859 Hall proposed the name *Strophostylus* for some coiled platyceratid shells quite similar to *Diaphorostoma* in most respects but with a distinct revolving fold on the columella (16, p. 303). Unfortunately there was included among the species described by Hall at the time the genus was proposed a new species which he felt possessed the characters of the genus but the aperture of which he had not actually seen. This was *S. elegans* Hall, subsequently selected as the genotype by S. A. Miller (9, p. 427). As I

have had occasion to show recently (1e, p. 35), the cleaning away of the matrix from the aperture of one of Hall's types proves *S. elegans* to be something entirely different from what Hall supposed, and the name *Strophostylus* must follow the validly designated genotype species which is seemingly referable to the Trochoturbinidae. The platyceratids, with a twisted columella, for which Hall had intended the name, are thus left nameless. I therefore propose for them the name *Helictostylus* Knight, n. gen., with *Strophostylus andrewsi* Hall (16, p. 472) as the genotype (from the Greek ἑλικτός, rolled, wound, and στῦλος, pillar, post).

KEY TO THE AMERICAN PENNSYLVANIAN SPECIES OF *Straparollus*

A[1] Base of whorls rounded, or only slightly angulated at adult stages.

B[1] Form a low cone, umbilicus deep.

C[1] Whorls rounded and with three rounded, revolving ridges..... .....*S.* (*s.s.*) *savagei*. Page 149

C[2] Whorls flattened above, with an angulated shoulder..... .....*S.* (*E.*) *umbilicatus*. Page 151

B[2] Form discoidal, with conspicuous, but shallow umbilicus, whorls flattened above, with angulated shoulder.

C[3] Base of whorls angulated in young but rounded at adult stages..... .....*S.* (*E.*) *plummeri*. Page 152

C[4] Base of whorls with a row of regularly spaced, rounded nodes, upper carina low, rounded..... .....*S.* (*E.*) *pernodosus*. Page 145

C[5] Base of whorls with a row of regularly spaced rounded nodes, upper carina sharp, elevated..... .....*S.* (*E.*) *serratus*. Page 154

A[2] Base and upper shoulder of whorls sharply angulated, often carinate, whorl section externally subtrapezoidal.

B[3] Form discoidal, spire concave, base slightly concave, almost flat, outer whorl face without sharp, revolving thread.

C[6] Upper whorl surface gently convex, lower whorl surface gently convex, carinae low, sutures sharp, grooves above and below..... .....*S.* (*E.*) *reedsi*. Page 159

C[7] Upper whorl surface nearly flat, lower whorl surface, gently concave, carinae low, sutures sharp grooves above, linear below..... .....*S.* (*E.*) *catilloides*. Page 155

C[8] Upper whorl surface markedly concave, lower whorl surface gently concave, carinae markedly elevated, sutures linear..... .....*S.* (*E.*) *subrugosus*. Page 157

C[9] Upper whorl surface, flat within wall-like upper carinae, lower whorl surface gently concave, upper carina thin, even, not crenulated, sutures linear..... .....*S.* (*E.*) *muricatus*. Page 160

C[10] Upper and lower whorl surfaces flat, carinae low, sharp fluted, sutures, linear, outer whorl face with distinct revolving sulcus within lower angulation..... .....*S.* (*E.*) *subsulcatus*. Page 161

C[11] Upper whorl surface concave, upper carina low, even, base gently concave..... ..*S.* (*E.*) *hollingsworthi*. Page 155

B[4] Form discoidal, spire concave, base concave, upper carina with strong rugosities, a sharp, revolving thread on outer whorl face below upper carina. C[12] .. *S.* (*E.*) *subquadratus*. Page 162

DESCRIPTION OF SPECIES

Family EUOMPHALIDAE de Koninck, 1881

Genus STRAPAROLLUS Montefort, 1810
Subgenus STRAPAROLLUS Montfort, 1810

STRAPAROLLUS (STRAPAROLLUS) SAVAGEI Knight, n. sp.
Plate 21, figures 1*a–e*

Euomphalus n. sp. PLUMMER AND MOORE, Texas Univ., Bull. 2132, pl. 7, figs. 9–10. Smithwick shale, Bend group, Pennsylvanian, San Saba County, Texas.

Measurements of *Straparollus* (*Straparollus*) *savagei*

	A	B	C
Number of whorls	$5\frac{1}{2}^a$	$5\frac{1}{2}^b$	7^a
Height	6.25 mm.	6.0 mm.	10.0 mm.
Width	11.0 mm.	12.0 mm.	20.0 mm.[c]
Ratio of height to width	0.57	0.50	0.50

A. The holotype, a half-grown individual (Pl. 21, figs. 1*b–e*).
B. A paratype, (not figured).
C. A large individual (Pl. 21, fig. 1*a*).
a Estimated on the assumption that $1\frac{1}{2}$ apical whorls are missing.
b Estimated on the assumption that $3\frac{1}{2}$ apical whorls are missing.
c Estimated with an allowance for the distortion of the final whorl.

Shell with the characters of the subgenus, but with three distinct rounded, subangular revolving ridges; apex, including first three whorls, flattened, subsequent whorls forming low cone; umbilicus deep with nearly vertical sides; first two whorls (nepionic) rounded, the revolving ridges appearing gradually on the third whorl (neanic); ephebic whorls with rather narrow horizontal, flattened band next the upper suture; another flattened band, inclined about 45° from the horizontal lies between the upper angulation and the second angulation which passes around the periphery at about mid-whorl height; a third somewhat flattened band, sloping inward from the peripheral angulation at about 45°, occupies the lower half of the whorl face and is bounded below by the low, rounded basal angulation or ridge, the most obscure of the three ridges; umbilical profile of the whorl rounded; upper suture shallow, passing around the previous whorl at the crest of the peripheral ridge; growth-lines passing downward around the whorls with a very slight insinuation over the upper revolving ridge and a very slight obliquity; outer shell layer strongly pigmented, seemingly with no pattern, though occasional irregularly placed lighter colored incremental margins aid in marking out growth-lines.

S. savagei is placed in the typical subgenus with some hesitancy. Indeed it is closely on the border line between the typical subgenus and *Euomphalus*, a

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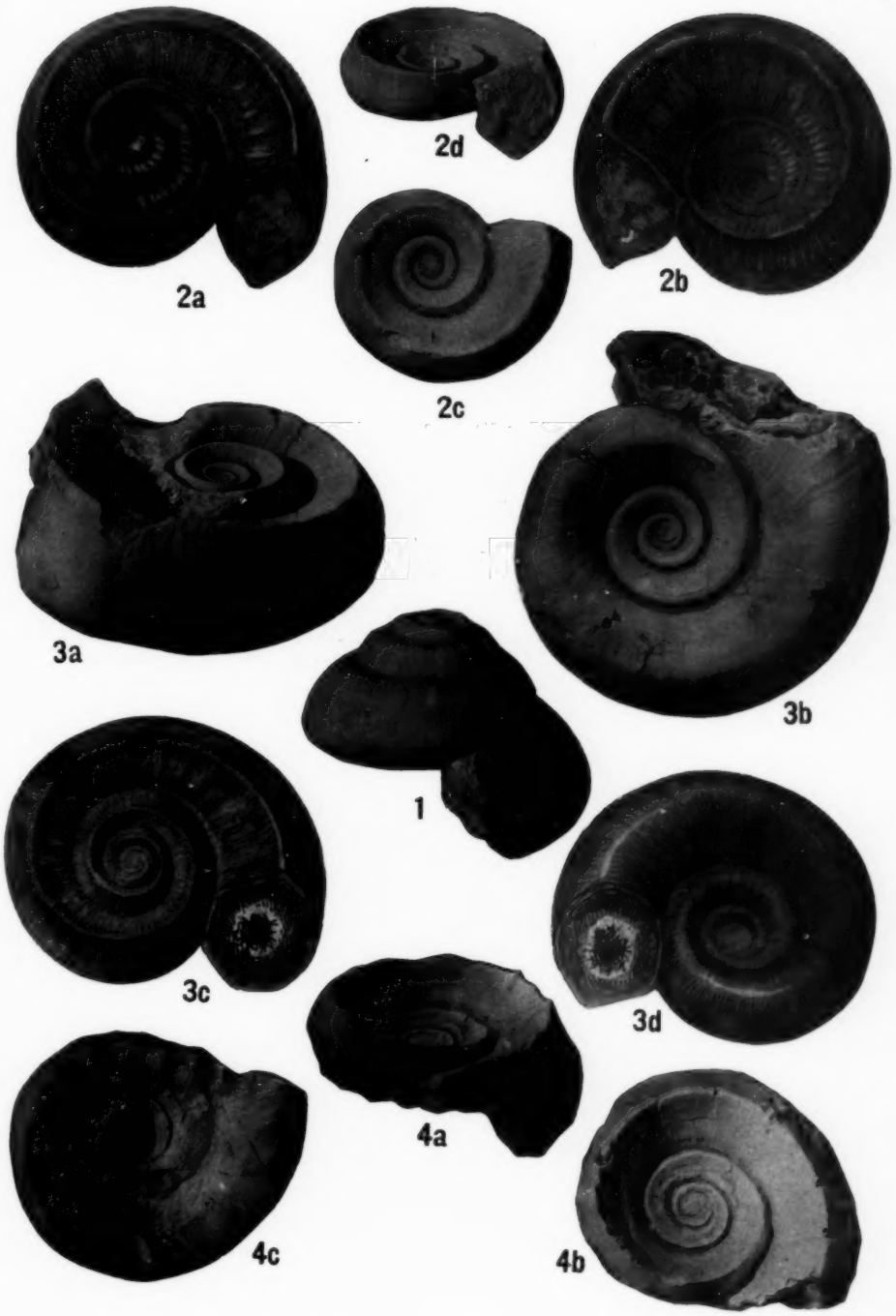
EXPLANATION OF PLATE 20

FIG. 1—*Straparollus* (*Straparollus*) *dionysii* ? Montfort, (×2). Specimen from the Mountain limestone (Mississippian) at Welton England. (Yale Peabody Museum No. 14280). This specimen seems to be a typical example of the genotype of *Straparollus* Montfort, yet I hesitate to identify it positively from the literature. At any rate it is a typical example of the genus, even if not certainly of the genotype species, and will serve to illustrate the generic characters. Note the faint shouldering on the whorls differing only in degree of expression from that shown by *S.* (*S.*) *savagei* (Pl. 21, figs. 1*a–e*).

2*a–d*—*Straparollus* (*Euomphalus*) *catillus* (Sowerby), the genotype of *Schizostoma* Bronn. *a* and *b*, The holotype after Sowerby; *a*, oblique apical view; *b*, oblique basal, view. *c* and *d*, A specimen from the Mountain limestone at Welton, England (×1) (Yale Peabody Museum No. 14281); *c*, basal view; *d*, oblique apical view.

3*a–d*—*Straparollus* (*Euomphalus*) *pentangulatus* (Sowerby), the genotype of *Euomphalus* Sowerby. *a* and *b*, A specimen from the Mountain limestone at Welton, England, (×1) (Yale Peabody Museum No. 14282); *a*, oblique apical view; *b*, basal view. *c* and *d*, The holotype, after Sowerby; *c*, oblique apical view, *d*, oblique basal view. Note the sharply angulated base of the earlier whorls, quite similar to the same character in *S.* (*E.*) *catillus*. It seems possible that *S.* (*E.*) *catillus* may have been founded on a young example of *S.* (*E.*) *pentangulatus*. That the specimens figured by Sowerby seem to be about of a size may mean little since Sowerby gives us no clue to the relative size of his illustrations.

4*a–c*—*Straparollus* (*Euomphalus*) *serratus* Knight n. sp. Page 154. All figures ×1. Oblique apical, basal and apical views, respectively, of the holotype. The spire is a little mashed though seemingly not much.



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border line that is admittedly not a sharply defined one, and provides an excellent illustration of how the two subgenera may intergrade. It is the obtusely rounded character of the revolving ridges, together with the conical form of the species, that leads me to place it with typical subgenus, *Straparollus* in the strict sense.

S. savagei is easily distinguished by its three, subangular revolving ridges. The only American Pennsylvanian species that approaches it in its widely conical form is *S. umbilicus* Meek and Worthen, which because of its single, rather sharply angulated shoulder and wide, flattened upper whorl-surface, I am placing in the subgenus *Euomphalus*.

The name is in honor of Prof. T. E. Savage of the University of Illinois, who has so generously loaned me for study the types of many of Meek and Worthen's gastropod species.

I have before me two collections of *S. savagei* containing twelve specimens in all, both collections from the Smithwick shale, Bend group, San Saba County, Texas.

Types, Yale Peabody Museum No. 14296 and 14243.

Subgenus EUOMPHALUS Sowerby 1812.
Group of EUOMPHALUS PENTANGULATUS Sowerby

STRAPAROLLUS (EUOMPHALUS) UMBILICATUS Meek and Worthen
Plate 21, figures 2*a–e*

Euomphalus umbilicatus MEEK AND WORTHEN, *1860*, Acad. Nat. Sci. Philadelphia, Proc. p. 462. Pennsylvanian, St. Clair County, Illinois.—*Straparollus umbilicatus* (Meek and Worthen) MEEK AND WORTHEN, *1866*, Illinois Geol. Survey, vol. 2, p. 362, pl. 29, figs. 1*a–c*. Pennsylvanian, St. Clair County, Illinois.

Shell with the characters of the subgenus, but with a distinctly higher spire and more conical form than the more typical species; apex, including first three whorls (nepionic), flattened or even slightly concave, subsequent whorls forming a low cone; umbilicus deep, with nearly vertical sides; first two whorls probably rounded (but not seen), the rather sharp angulation at the shoulder arising gradually on subsequent whorls, until it is well developed at the fifth whorl; ephebic whorls with relatively broad, flattened, horizontal band between the upper suture and the angulation at the shoulder; sides of whorl profile slightly concave just below the angulation, and thence rather sharply rounded over the periphery at mid-whorl, and again sharply rounded below; umbilical profile of the whorl rounded; upper sutures sharply re-entrant, passing around the previous whorl approximately at the periphery; growth lines pass across the flattened area with a slight backward swing from the upper suture, cross the angulation with a very slight sinus, thence downward across the whorl-face with a slight forward convexity and backward obliquity, and around the base of the whorl with a slight concavity; outer shell-layer strongly pigmented, seemingly with a uniform dark color.

S. (*E.*) *umbilicatus* is closest in form to *S.* (*S.*) *savagei* Knight, n. sp., but has a wider horizontal band above the shoulder angulation, while the lateral and basal angulations of the latter species are represented on the former only by a somewhat sharper rounding of the whorl profile.

Through the courtesy of Prof. T. E. Savage of the University of Illinois, I

Measurements of *Straparollus* (*Euomphalus*) *umbilicatus*

	A	B
Number of whorls	8[a]	6½[a]
Height	17 mm.[b]	7 mm.
Width	30 mm.[b]	14.5 mm.
Ratio of height to width	0.57	0.48

A. Meek and Worthen's holotype (Pl. 21, fig. 2*a*).
B. My cyrioplesiotype (Pl. 21, figs. 2*c–e*).

a Estimated on the assumption that four apical whorls are missing or obscured.
b Estimated with an allowance for the distortion of the specimen.

have before me Meek and Worthen's holotype, a large and none too well preserved specimen. Meek and Worthen stated that their specimen came from St. Clair County, Illinois, and one familiar with fossils from that region does not hesitate to assign it to the Piasa (=Pawnee) limestone on the evidence of certain peculiarities of matrix and preservation. I have three specimens from the St. Louis outlier, one from the basal Pawnee limestone at Loc. 43, and two from the lower Fort Scott limestone at Loc. 7.

My figured plesiotypes bear Yale Peabody Museum Nos. 14244 and 14295.

STRAPAROLLUS (EUOMPHALUS) PLUMMERI Knight, n. sp.

Plate 22, figures 3*a–h;* Plate 26, figure 7.

Euomphalus n. sp. PLUMMER AND MOORE, *1921*, Texas, Univ., Bull., 2132, pl. 19, figs. 12–15, Brownwood shale, Canyon group, Pennsylvanian, near Brooksmith, Texas.

Shell with the characters of the subgenus in its most typical expression; apex, slightly concave for the first six whorls, spire protruding only at the seventh whorl; umbilicus concave and very wide; first two (nepionic) whorls rounded; the sharp angulation of tne upper and lower shoulders arising gradually in the third whorl, the upper angulation continuing throughout but the lower one grading gradually into a sharply rounded, somewhat obscure ridge in the sixth whorl; upper sutures sharply incised; upper whorl surface flattened between inner suture and sharp angulation, dipping inward toward the depressed apex in the earlier whorls and gradually becoming horizontal toward the end of the seventh whorl; lateral whorl-face gently and evenly convex; umbilical surface of the whorl very slightly concave near the lower revolving ridge; more strongly convex as the umbilical suture

Measurements of *Straparollus* (*Euomphalus*) *plummeri*

	A	B	C
Number of whorls	7[a]	6½[b]	5½[b]
Height	21.5 mm.	15.5 mm.	7.5 mm.
Width	55. mm.	42. mm.	21.5 mm.
Ratio of height to width	0.39	0.37	0.35

A. A topoparatype, my largest specimen (Pl. 22, figs. 3*f–h*).
B. The holotype, an example of average size (Pl. 22, figs. 3*c–e*).
C. A paratype, a small specimen (Pl. 22, figs. 3*a–b*).

a Estimated on the assumption that the initial whorl is obscured.
b Estimated on the assumption that two apical whorls are obscured.

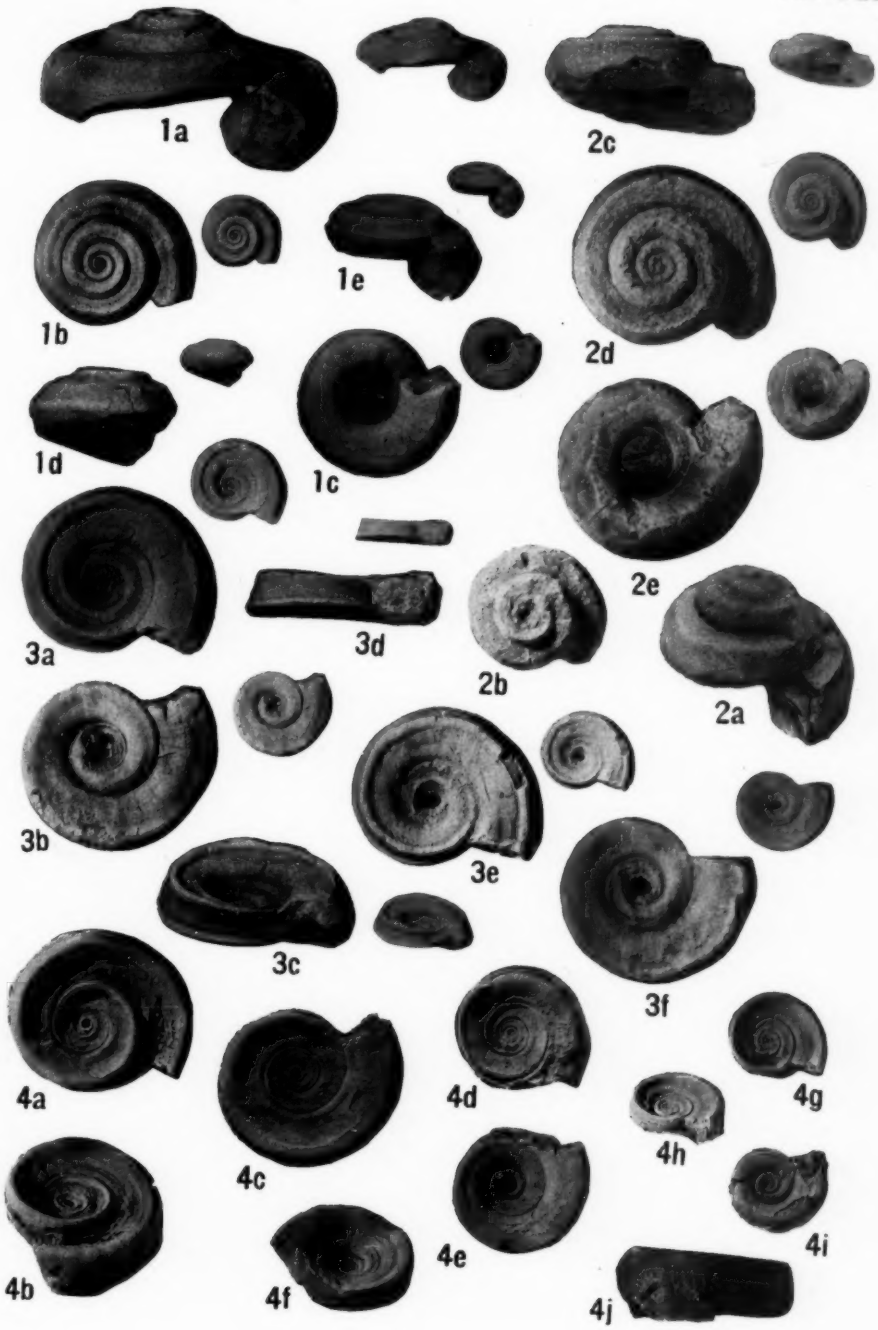
EXPLANATION OF PLATE 21

FIGS. 1*a–e*—*Straparollus* (*Straparollus*) *savagei* Knight, n. sp. Page. 149. All figures ×2. Specimens from the Smithwick shale, San Saba County, Texas. *a*, The largest paratype, somewhat distorted and broken. *b–e*, The holotype; *b*, apical view; *d*, side view; *e*, oblique apical view. The holotype is not a fully grown specimen and has not assumed fully the subconical form of later growth.

2*a–e*—*Straparollus* (*Euomphalus*) *umbilicatus* (Meek and Worthen) Page 151. *a*, Meek and Worthen's holotype (×1), from St. Clair County, Illinois. A distorted specimen. *b*, My largest plesiotype, (×1), from the Pawnee limestone, St. Louis outlier, Locality 43. Apical view. *c–e*, A plesiotype (×2), from the lower Fort Scott limestone, St. Louis outlier; *c*, apertural view; *d*, apical view; *e*, basal view. The holotype, though considerably distorted, shows the subconical form assumed when fully grown.

3*a–f*—*Straparollus* (*Euomphalus*) *muricatus* Knight, n. sp. Page 160. Specimens from the Lower Permian at Hooser, Kansas. All figures ×2. *a–d*, The holotype; *a*, apical view; *b*, basal view; *c*, oblique apical view. *d*, apertural view. *e* and *f*, Apical and basal views, respectively of a paratype.

4*a–j*—*Straparollus* (*Euomphalus*) *hollingsworthi* Knight, n. sp. Page 155. All figures ×1, except *j*. *a*, *b*, *c*, Apical, oblique apical and basal views, respectively, of the largest paratype. *d*, *e*, *f*, apical, basal, and oblique basal views, respectively, of the holotype. *g*, *h*, *i*, *j*, Apical, oblique apical, and side basal views of the smallest paratype. *j* is ×2.



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is approached; growth lines on upper flattened area, very slightly oblique backward and convex forward, a very faint sinus over the upper angulation, on the sides rather strongly convex on the upper half of the whorl-face and nearly straight though oblique backwards and downwards on the lower half, on the umbilical surface, concave forward; outer shell layer strongly pigmented, especially in a zone about both the upper and lower angulations.

This large handsome species is very similar to the genotype, *S.* (*E.*) *pentangulatus* Sowerby, though readily distinguishable on close comparison. It does not carry the evenly arranged nodes on the basal ridge shown by *S.* (*E.*) *pernodosus* Meek and Worthen and its growth-lines follow a somewhat different course. Young individuals, in which the apex is distinctly concave and both the upper and lower angulations quite sharp, may be distinguished from *S.* (*E.*) *catilloides* and its closer allies by the relatively deeper umbilicus, lack of distinct, elevated carinae and by the course of the growth lines which are much as in the adult. It is larger and coarser than *S.* (*E.*) ***hollingsworthi*** and its sutures are deeply incised whereas in that species the sutures are linear.

The name is in honor of Mr. Frederick B. Plummer of the Texas Bureau of Economic Geology and Technology.

I have before me through the courtesy of Prof. Carl O. Dunbar of Yale and Dr. Norman D. Newell of Yale and the Kansas Geological Survey, 41 specimens referable to this species, many of them young individuals. These specimens were derived from the following horizons and localities. None of them are from the St. Louis outlier.

Cisco group, 3½ miles SE. of Jacksboro, Texas, Yale Peabody Museum No. 14245..... 1

Cisco group, Jacksboro limestone, 10½ miles SE. of Graham, Texas. Yale Peabody Museum No. 14246..... 1

Canyon group, Grayford formation, Grayford, Texas, Yale Peabody Museum No. 14247..... 2

Canyon group, Palo Pinto formation, 3 miles W. of Strawn, Texas. Yale Peabody Museum No. 14248..... 5

Canyon group, Palo Pinto formation, 13 miles W. of Mineral Wells, Texas, Yale Peabody Museum No. 14249... 4

Canyon group, near base; near Palo Pinto, Texas. Yale Peabody Museum No. 14290..... 5

Westerville limestone (?), Kansas City group, Westport, Missouri, Yale Peabody Museum No. 14250..... 3

Westerville limestone, Kansas City group, Kansas City, Missouri, Yale Peabody Museum No. 14251..... 2

Argentine limestone, Kansas City group, Bonner Springs, Kansas, Univ. of Kansas Coll..... 7

Farley limestone, Kansas City group, Bonner Springs, Kansas, Univ. of Kansas Coll..... 3

Upper part of Plattsburg limestone, Lansing group, Univ. of Kansas Coll., Bonner Springs, Kansas. SW. cor., sec. 6, T. 17 S., R. 20 E., Bert Pass quarry..... 1

Vilas shale, base, Lansing group, Univ. of Kansas Coll., Center SW. ¼, sec. 11, T. 20 S., R. 19 E., Anderson County, Kansas..... 6

Stanton limestone, lower part, Lansing group, 1 mile NE. of Eudora, Kansas. Univ. of Kansas Coll..... 3

Stanton limestone, middle part, Lansing group, Cement plant, Fredonia, Kansas., Univ. of Kansas Coll..... 2

Stanton limestone, upper part, Lansing group, Center S. side, sec. 17, T. 21 S., R 19 E., road cut, SW. of Garnett, Kansas. Univ. of Kansas Coll..... 1

STRAPAROLLUS (EUOMPHALUS) SERRATUS
Knight, n. sp.

Plate 20, figures 4*a–c*

Shell with the characters of the subgenus, with phymatiferid nodes below and a sharp, serrated carina above; apex markedly concave; umbilicus rather gently concave; upper sutures deeply incised; lower sutures shallow, almost linear; upper whorl surface convex near the inner suture, gently concave for the outer two-thirds; upper carina sharp, elevated, but not wall-like, with gentle flutings and a few sharp points; outer whorl-face very gently concave above, rather strongly convex below, the upper two-thirds sloping gently inwards; lower whorl surface gently convex, the lower angulation sharply rounded and carrying rounded, evenly spaced nodes of which there are sixteen on the final whorl; growth lines on the upper whorl surface nearly radial, gently convex forward, on the outer whorl face convex above and nearly straight and oblique backward below, on the lower surface oblique backwards toward the inner suture and concave forward; pigmentation unknown.

This species is characterized by its phymatiferid nodes below, its concave spire and sharp elevated and serrated carina. Its phymatiferid nodes recall *S.* (*E.*) *pernodosos* Meek and Worthen but its sharp carina and nearly radial growth-lines on the upper whorl surface serve to distinguish it at a glance.

The holotype and only specimen (Yale Peabody Museum No. 14289) is from the Marble Falls limestone of the Bend group, 3½ miles south of San Saba, Texas.

Measurements of *Straparollus* (*Euomphalus*) *serratus*

	A
Number of whorls	6½[a]
Height	17.0 mm.
Width	42.0 mm.
Ratio of height to width	0.40

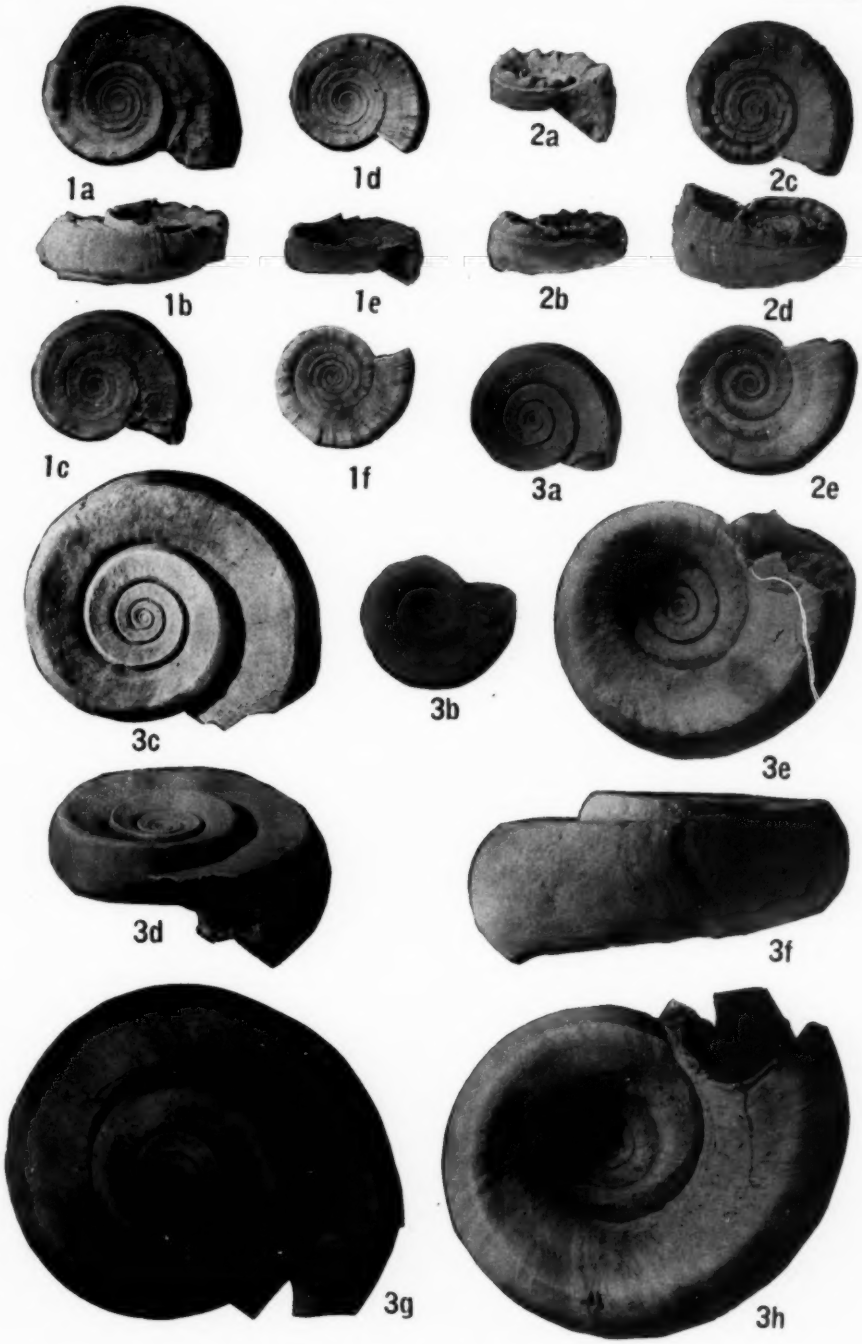
A. The holotype, and only specimen.
a Estimated, the earlier whorls are obscured.

EXPLANATION OF PLATE 22

FIGS. 1*a–f*—*Straparollus* (*Euomphalus*) *subsulcatus* Knight, n. sp. Page 161. All figures ×1. *a* and *b*, Apical side views of the largest paratype. The last eighth of the final whorl is slightly mashed. *c*, A paratype. *d*, *e* and *f*, Apical, oblique apertural and basal views, respectively, of the holotype, a very well preserved, but not fully grown, individual. The first and last mentioned specimens are from the Nowata shale north of Talala, Oklahoma, and the other, (fig. 1*c*) is from above the Checkerboard limestone, in sec. 29, T. 13 N., R. 10 E., Oklahoma.

2*a–e*—*Straparollus* (*Euomphalus*) *subquadratus* Meek and Worthen. Page 162. All figures ×1. *a*, A plesiotype from the Hoxbar formation south of Ardmore, Oklahoma, oblique apertural view. *b*, Oblique, side view of a plesiotype from the *Uddenites* zone of Wolfcamp, near Marathon, Texas. *c*, *d* and *e*, Apertural, oblique side and basal views, respectively, of the cyrioplesiotype from the Wewoka formation at Okmulgee, Oklahoma. Note especially the revolving thread on the whorl-face, just below the crenulated upper carina.

3*a–h*—*Straparollus* (*Euomphalus*) *plummeri* Knight, n. sp. Page 152. All figures ×1. *a* and *b*, Apical and basal views, respectively, of a paratype, a young specimen from Westport, Missouri. Note the sharp angulation on the base at young stages. *c*, *d* and *e*, The holotype, apical, basal, and oblique-apical views, respectively. A specimen not quite fully grown. *f*, *g* and *h*, Side, apical and basal views, respectively, of a topoparatype. The two specimens last mentioned are from the Grayford formation, near Grayford, Texas.



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STRAPAROLLUS (EUOMPHALUS) HOLLINGSWORTHI Knight, n. sp.

Plate 21, figures 4*a–j*

Shell with the characters of the subgenus; apex and base sub-equally concave for the first six whorls, the spire protruding slightly and the base, or umbilicus deepening slightly in the seventh; sharply angulated upper shoulder with a low, even carina; lower shoulder angulated and with an obscure carina at neanic stages, the lower angulation becoming gentler and more rounded at later stages; upper sutures linear, not incised until the slight protrusion of the spire in the seventh whorl gives it relief; lower suture linear, though somewhat deepened at seventh whorl; upper whorl surface concave within upper carina, sloping gently inward; lateral whorl-face very gently convex, almost flat; lower whorl face gently convex near inner suture, gently concave or flat over most of its surface; growth-lines passing across the upper whorl-surface almost radically, slightly convex forward, on the outer whorl-face slightly convex forward on the upper half and nearly straight and slightly oblique below, on the base with a gentle forward concavity, pigmentation concentrated on the carinae.

S. (*E.*) *hollingsworthi* is intermediate in form between the group of *E. pentangulatus* and *E. catilloides*, though the slight elevation of its spire and the rounding out of the lower carina at late stages show that its affinities are probably with the former. It is a smaller and somewhat more delicate shell than *S.* (*E.*) *plummeri* and is easily distinguished from it by its upper sutures being linear and not incised. Its upper whorl surface is also more concave. In size and general shape it approaches *S.* (*E.*) *subsulcatus* but lacks the revolving furrow on the whorl and the fluted carina of that species. Adult specimens are notably larger than *S.* (*E.*) *catilloides* and its closer allies, and the more concave base and lack of rugosities on the carinae serve to distinguish the young.

I have four specimens of this species in a collection of gastropods from the middle of the Boggy shale, center of sec. 17, T. 2 N., R. 7 E., Pontotoc County, Oklahoma. The collection was generously presented to me by Mr. R. V. Hollingsworth of the University of Oklahoma, in honor of whom the species is named.

The types bear Yale Peabody Museum No. 14287.

Measurements of *Straparollus* (*Euomphalus*) *hollingsworthi*

	A	B	C
Number of whorls	6½[a]	6	5½
Height	8.5 mm.	6.0 mm.[b]	4.75 mm.
Width	25.0 mm.	18.25 mm.	13.5 mm.
Ratio of height to width	0.34	0.33	0.35

A. A paratype, the largest specimen. (Pl. 21, figs. 4*a–c*).
B. The holotype (Pl. 21, figs. 4*d–f*).
C. A paratype, (Pl. 21, figs. 4*g–i*).
a Estimated on the assumption that first three whorls are missing. The specimen has also lost half the final whorl. It originally had seven full whorls.
b Making allowance for compression and breakage.

Group of EUOMPHALUS CATILLOIDES Conrad

STRAPAROLLUS (EUOMPHALUS) CATILLOIDES (Conrad)

Plate 23, figures 2*a–l*; Plate 26, figure 4.

Inachus catilloides CONRAD, *1842*, Acad. Nat. Sci. Philadelphia, Jour., (1), vol. 8, pt. 2, p. 273, pl. 15, fig. 3., Brush Creek limestone, Conemaugh series, Pennsylvanian, Bens Creek, Pennsylvania.[4]

Euomphalus catilloides (Conrad) RAYMOND, *1910*, Carnegie Mus. (Pittsburgh), Annals, vol. 7, no. 1, p. 157, pl. 25, fig. 5, Brush Creek limestone, Conemaugh series, Pennsylvanian, Donohoe, Pennsylvanian.

Schizostoma catilloides (Conrad), GIRTY, *1915*, U. S. Geol. Survey, Bull. 544, p. 179, pl. 21, figs. 4–5*b*, Wewoka formation, Pennsylvanian, Coalgate quadrangle, Oklahoma.

[4] For exact horizon and locality, see Raymond, cited below.

Measurements of *Straparollus* (*Euomphalus*) *catilloides*

	A	B	C	D	E
Number of whorls	5½	5⅝	5¾	5⅝	5⅝
Height	3.80 mm.	4.0 mm.	4.0 mm.	3.0 mm.	3.0 mm.
Width	11.0 mm.	13.00 mm.	15.0 mm.	11.75 mm.	11.25 mm.
Ratio of height to width	0.35	0.31	0.27	0.26	0.235

A. A specimen from the type horizon near the type locality (Pl. 23, figs. 2*a–c*).
B. A specimen from the Wewoka formation, Oklahoma (Pl. 23, figs. 2*d–f*).
C. A very large specimen from the Kansas City group, Missouri (not figured).
D. A specimen from the Coffeyville formation, Oklahoma (Pl. 23, figs. 2*g–i*).
E. A specimen from the Hoxbar formation, Oklahoma (Pl. 23, figs. 2*j–l*).

Discoidal, planospirally coiled shells with the characters of the subgenus and more particularly of the group of which the species is typical; almost symmetrically coiled; spire and base both gently concave, the spire always more so than the base; the base, or umbilicus, nearly flat in some specimens; upper suture a sharp groove; whorl section externally trapezoidal; upper whorl surface sloping inward, gently convex near the inner suture, even more gently concave on the outer two-thirds, bordered by a well marked but not extremely developed carina at the upper angulation; upper carina gently undulating at earlier stages, sometimes with imbricating rugosities at later stages; outer whorl-face nearly vertical, gently convex in the middle with faint sulci near the carinae, the lower one more conspicuous on some specimens; lower carina well marked, but not extreme, forming the widest part of shell, with a well marked bourrelet on the basal side; base of the whorl within the bourrelet nearly flat; basal sutures linear; growth lines crossing upper whorl-surface with very slight backward obliquity, with no sinus at upper angle, passing across outer whorl-face with very slight obliquity, and very slight median convexity, crossing the lower carina directly and across the base to the lower suture with a very slight concavity; pigmentation of outer shell layer a little stronger on the carinae than on the flat surfaces.

S. (*E.*) *catilloides* is characterized by the slight concavity of its upper whorl-surfaces and the more moderate development of its upper carina as compared with *S.* (*E.*) *subrugosus*. As compared with *S.* (*E.*) *reedsi*, its upper surface is more concave and its carinae are more strongly developed. Its sutures both above and below are not so sharply ex-

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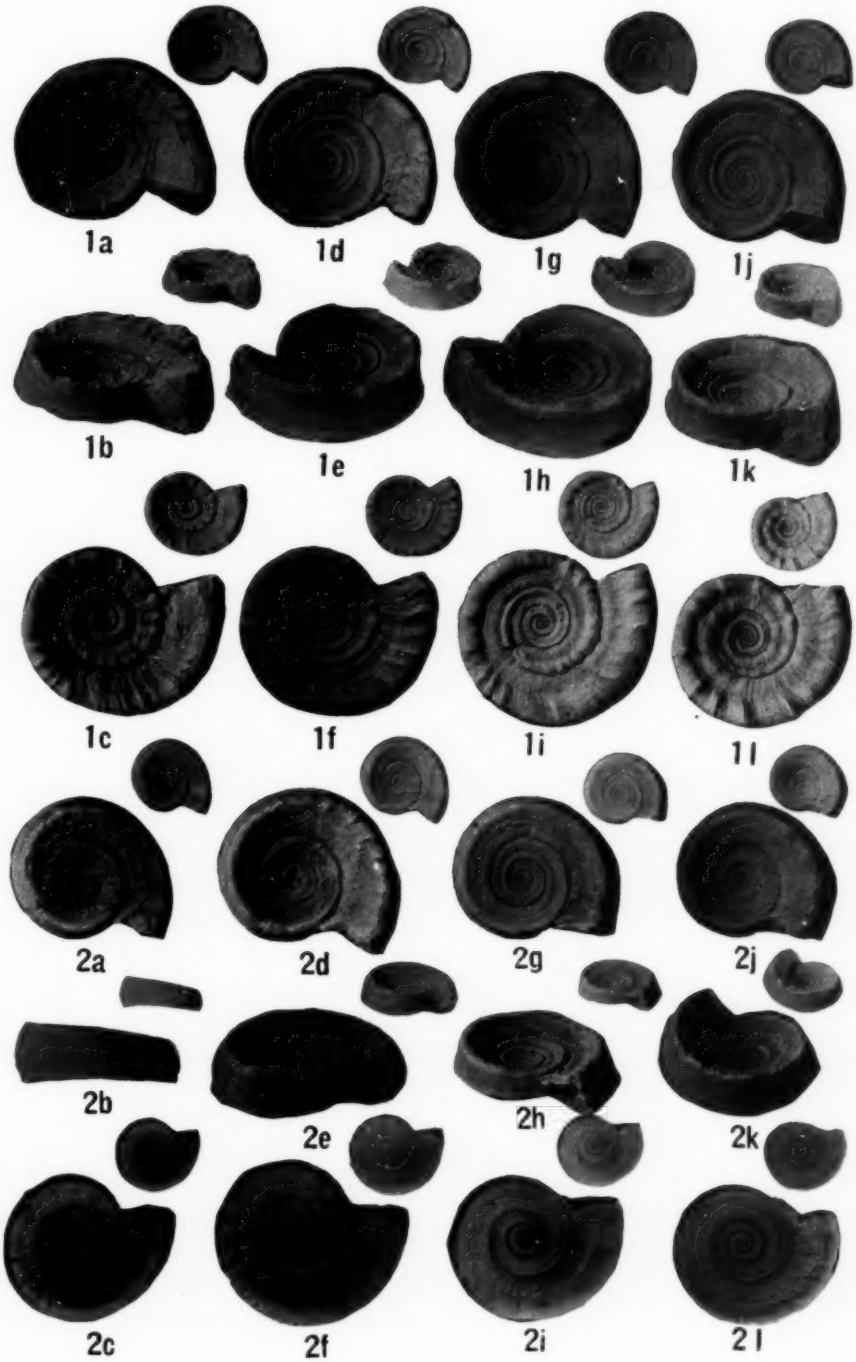
EXPLANATION OF PLATE 23

FIGS. 1*a–l*—*Straparollus* (*Euomphalus*) *subrugosus* Meek and Worthen. Page 157. All figures ×2. *a*, *b* and *c*, The holotype, also holotype of *E. rugosus* Hall, not Sowerby, from the "Coal Measures," Illinois. Specimen in the American Museum of Natural History. *a*, Apical view. *b*, Oblique apical view. *c*, Basal view. *d–l*, Apical, oblique apical and basal views of three plesiotypes from the Jacksboro limestone, Cisco group, near Graham, Texas. Note the relatively chunky, square-sided form, the strong, rugose bourrelet on the base, the high upper carina, concave upper whorl-surface, and the deeply concave spire with the inner whorls nestling deep within the last whorl.

2*a–l*—*Straparollus* (*Euomphalus*) *catilloides* (Conrad). Page 155. All figures ×2. *a*, *b* and *c*, Apical, side and basal views, respectively, of one of Raymond's plesiotypes from the type horizon, near the type locality. The specimen is somewhat distorted and it is not well cleaned. The rounded whorl-face is in part due to mashing. *d*, *e* and *f*, Three views of a specimen from the Wewoka formation of Oklahoma. *g*, *h* and *i*, Three views of a specimen from above the Checkerboard limestone, Okfuskee, Oklahoma. *j*, *k* and *l*, Three views of a specimen from the Hoxbar formation, near Ardmore, Oklahoma. Note the relatively smooth bourrelet on the base and the weak upper carina.



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cavated as in *S.* (*E.*) *reedsi*. It does not have the rather high, even, wall-like upper carina of *S.* (*E.*) *muricatus*. It is smaller than *S.* (*E.*) *subsulcatus*, more nearly plano-spiral in form and has more strongly developed carinae.

The very short synonymy cited above requires little comment. Of the forms usually cited I have omitted many of the customary citations since they are unrecognizable in any narrow sense from the figures and descriptions. Others will appear under *S.* (*E.*) *subrugosus* Meek and Worthen. The three citations given appear to be the only ones of the long list usually cited with a valid claim to recognition as dealing with *S.* (*E.*) *catilloides* in a narrow sense.

Thanks to the courtesy of Dr. I. P. Tolmachoff of the Carnegie Museum, I have before me the five specimens figured by Raymond (loc. cit.) from the Brush Creek limestone at Donohoe, Pennsylvania. Professor Raymond has shown that Conrad's specimens were from the same horizon at Bens Creek, Pennsylvania, not far away. These specimens thus are virtually toptotypes and serve to fix the species in the narrower sense, an impossibility from Conrad's description and figure alone. I am also referring to this species the following specimens in the Peabody Museum at Yale.

Nine specimens, Wewoka formation, SW. ¼, sec. 33, T. 5 N., R. 8 E., Coalgate quadrangle, Oklahoma. Yale Peabody Museum No. 14252.

Four specimens, Chanute shale (?), Kansas City group, Turkey Creek, Kansas City, Missouri. Yale Peabody Museum No. 14253.

Three specimens, Coffeyville formation, above Checkerboard limestone, near center sec. 22, T. 13 N., R. 10 E., near Okfuskee, Oklahoma. Yale Peabody Museum No. 14254.

One specimen, Hoxbar formation (?), about 7 miles west, and 2 miles south of Ardmore, Oklahoma. Yale Peabody Museum No. 14255.

Eighty-one specimens, Hoxbar formation, central east sec. 10, T. 5 S., R. 1 E., 2 miles west and 4 miles south of Ardmore, Oklahoma. Yale Peabody Museum No. 14256.

In addition, Dr. Norman D. Newell has loaned me two specimens that seem to be referable to the species though their preservation leaves something to be desired.

One specimen, base of Weston shale, at old brick plant, center east ½ sec. 1, T. 9 S., R. 22 E., near Leavenworth, Kansas.

One specimen, Hickory Creek shale, Plattsburg formation, brick pit, 3 miles southwest of Chanute, Kansas.

STRAPAROLLUS (EUOMPHALUS) SUBRUGOSUS
Meek and Worthen
Plate 23, figures 1*a–l*; Plate 26, figures 6*a–b*

Euomphalus rugosus HALL, *1858*, Rept. Geol. Survey Iowa, vol. 1, pt. 2, p. 722, pl. 29, figs. 14*a–d*. Pennsylvanian, Illinois. (Not *Euomphalus rugosus* Sowerby, *1847*).

? *Serpula* (*Spirorbis*) *planorbites* (Münster), GEINITZ, *1866*, Carb. und Dyas in Nebraska, p. 3, pl. 1, fig. 6. Division C IV (lower part of Table Creek shale, Wabaunsee group), Pennsylvanian, Nebraska City, Nebraska.[5]

Straparollus (*Euomphalus*) *rugosus* (Hall), MEEK, *1872*, U. S. Geol. Survey Nebraska, Final Rept., p. 230, pl. 6, figs. 5*a*, 5*b*, pl. 11, figs. 4*a*, *b*, Divisions B and C. (Tarkio limestone, and Table Creek shale, Wabaunsee group) Pennsylvanian, Nebraska City, Nebraska.

Straparollus (*Euomphalus*) *subrugosus* MEEK AND WORTHEN, *1873*, Illinois Geol. Survey, vol. 5, p. 606, footnote. (This is a new name for *E. rugosus* Hall *1858*, preoccupied. The specimen figured by Meek and Worthen, loc. cit., plate 29, figures 11*a–c*, seems not to belong to that species, but to *S.* (*E.*) *reedsi* described herein.)

[5] The naming of the horizons of the Pennsylvanian at Nebraska City is from Condra, Nebraska Geol. Survey, Bull. 1, (2d ser.), pp. 118–119.

Measurements of *Straparollus (Euomphalus) subrugosus*

	A	B	C	D
Number of whorls	$5\frac{3}{4}$[a]	$5\frac{3}{4}$	$5\frac{5}{8}$	$5\frac{1}{2}$
Height	4.00 mm.	4.5 mm.	4.0 mm.	4.0 mm.
Width	13.75 mm.	13.75 mm.	13.25 mm.	12.75 mm.
Ratio of height to width	0.29	0.33	0.30	0.31

A. Hall's holotype (Pl. 23, figs. 1*a–c*).
B, C and D. Plesiotypes from the Jacksboro limestone of Texas (Pl. 23, figs. 1*d–l*).
[a] Estimated on the assumption that two apical whorls are missing.

Discoidal, planospirally coiled shells with the characters of the subgenus and more particularly of the group of *E. catilloides;* coiling distinctly asymmetrical; spire markedly concave; base much less so, typically, nearly flat; whorl section externally trapezoidal; upper suture linear, not excavated; upper whorl surface notably concave, strongly convex near the inner suture, then strongly concave within the high wall-like, crenulated carina of the upper angulation; outer whorl-face sloping very slightly inward above, essentially vertical above the protruding bourrelet of the lower carina; lower carina strongly developed with a well developed, crenulated bourrelet, lower whorl-face slightly concave within the broad bourrelet of the lower carina and very slightly convex next the inner suture; basal suture linear; growth lines above nearly straight, passing radially across the upper surface and carina; very slightly concave on the outer whorl-face and slightly concave on the lower whorl-surface; pigmentation of the outer shell layer concentrated about the carinae and the convexities near the sutures.

S. (E.) subrugosus is distinguishable from both *S. (E.) reedsi* and *S. (E.) catilloides* by its more deeply concave spire and the concavity of the upper whorl-surface between the stronger carina and stronger convexity next the inner suture. From *S. (E.) reedsi* it is further differentiated by the concavity of its lower whorl surfaces and its shallow, linear sutures. Its outer whorl face is also more nearly a flat surface, with only the lower carina protruding outside of it. *S. (E.) muricatus* is characterized by a smoother, less rugged expression and an upper carina that is smooth, wall-like and almost without crenulations. It hardly needs comparison with *S. (E.) subsulcatus* or *S. (E.) subquadratus.*

Due to the courtesy of Dr. Chester A. Reeds of the American Museum of Natural History, I have before me the holotype of *E. rugosus* Hall, which is also, through exact synonymy, the holotype of *S. (E.) subrugosus* Meek and Worthen. Unfortunately there is no information as to the exact horizon or locality from which the specimen came, except "Coal measures, Illinois." The specimen from near Springfield, Illinois, which Meek and Worthen identified with Hall's species when they proposed their new name, must be placed in a different species. Prof. T. E. Savage had been kind enough to lend me Meek and Worthen's specimen for comparison. Prof. P. A. Raymond of Harvard University has been so good as to permit me to study Geinitz' specimen from Nebraska City, and it is the juvenile stage of some otherwise unrecognizable euomphalid. I am including Geinitz' reference in the synonymy on the strength of Meek's later description and figures of specimens from the same horizon and locality. Other than the above citations, this species seems not to have appeared recognizably in the literature.

Besides Hall's holotype from Illinois, I have before me a paratype from Alpine Dam, Iowa, a specimen too poorly preserved to be recognizable, and probably a different species. From the Yale Peabody Museum collections, I have sixty-seven specimens, sixty-one of them in eight collections from the Cisco group of north-central Texas, (Yale Peabody Museum Nos. 14257 to 14264, inclusive) principally from the Jacksboro limestone

member though some are from the Gunsight limestone and the Wayland shale. One specimen is from the Ranger limestone in the Canyon group (Peabody Museum No. 14265). Also there are two specimens in one collection from the *Uddenites* zone, supposedly the base of the Permian, at Wolf Camp, Texas (Peabody Museum No. 14266), which are referred to the species with some hesitation. In addition to these Doctor Newell of the Kansas Geological Survey loaned me five specimens, three from near the top of the Stranger formation, base of the Douglas group, center sec. 22, T. 34 S., R. 12 E., near Niotaze, Chautauqua County, and two specimens from the same horizon a short distance north of Iatan, Kansas. Mr. R. V. Hollingsworth has furnished me with four specimens that must be referred to the species. These last (Yale Peabody Museum No. 14288) are from the Boggy shale in the NW. ¼ sec. 27, T. 3 N., R. 7 E., Pontotoc County, Oklahoma.

STRAPAROLLUS (EUOMPHALUS) REEDSI Knight, n. sp. Plate 24, all figures; Plate 26, figures 5*a–c*

Straparollus (*Euomphalus*) *subrugosus* MEEK AND WORTHEN, *1873*, Illinois Geol. Survey, vol. 5, p. 607, pl. 29, figs. 11*a–c*, roof shales of No. 8 Coal, Pennsylvanian, near Springfield, Illinois. (The specific name used by Meek and Worthen is proposed as a new name for *E. rugosus* Hall, preoccupied, with which they erroneously identified their specimen.)

Discoidal, planospirally coiled shells with the characters of the subgenus and more particularly of the group of *E. catilloides;* coiled somewhat asymmetrically, spire gently concave, but the outer edge of each whorl rises sharply above the inner edge of the next succeeding, base nearly flat; whorl section externally trapezoidal; upper sutures rather deep, groove-like; upper whorl-surface in general gently convex, sloping inward with only a very slight concavity next the low, irregularly crenulated carina of the upper angulation, outer whorl-face nearly flat, varying from a very slightly concave profile to one that is very slightly convex with a slight groove by the lower carina or by both the upper and lower carinae; lower carina weakly developed, rounded; lower whorl-surface rounded, slightly convex; lower sutures distinctly impressed; growth lines on upper whorl-surface nearly straight, very slightly oblique, crossing the upper carina without a sinus, on the outer whorl-face, nearly straight, very slightly oblique, on the base very slightly concave; outer shell layer strongly pigmented, in some specimens with seeming uniformity, in others concentrated on the carinae and near the sutures.

S. (*E.*) *reedsi* is distinguishable from the other species of the group of *S.* (*E.*) *catilloides* by the rounded surface of the base of the whorls and the consequently deeper basal sutures. The protrusion of

Measurements of *Straparollus* (*Euomphalus*) *reedsi*

	A	B	C	D	E	F
Number of whorls	5½	5⅝	5⅝	5	5	5
Height	3.75 mm.	3.5 mm.	3.5 mm.	2.5 mm.	2.5 mm.	2.75 mm.
Width	12.0 mm.	12.25 mm.	12.0 mm.	8.75 mm.	8.75 mm.	9.5 mm.
Ratio of height to width	0.31	0.29	0.29	0.29	0.29	0.29

A. A paratype (Pl. 24, figs. 3*a–c*).
B. A paratype (Pl. 24, figs. 2*a–c*).
C. The holotype (Pl. 24, figs. 1*a–c*).
D. A paratype (Pl. 24, figs. 6*a–e*).
E. A paratype (Pl. 24, figs. 5*a–e*).
F. A paratype (Pl. 24, figs. 7*a–c*).

the upper and outer edge of the inner whorls above the inner margin of the next succeeding whorls is also characteristic.

The type collection of this species is from the top of the Labette shale of the St. Louis, Pennsylvanian outlier at Locality 43. It contains sixty-three specimens from Zone G, one hundred and fifty-nine from Zone R, about five hundred specimens unallocated as to these two zones and innumerable juvenile specimens. The specimens for which measurements are given and the several of the figured specimens are all larger than the average size in the collection. The figured specimens bear Yale Peabody Museum Nos. 14267 and 14285. In addition to the collections from the type locality Prof. T. E. Savage of the University of Illinois has generously loaned me the specimen figured by Meek and Worthen (*loc. cit.*) from a very slightly higher horizon in Illinois. In the Peabody Museum collections there are five specimens (No. 14268) from Springfield, Illinois, one from the roof of the Danville coal at Danville, Illinois (No. 14269), one from Pike County, Kentucky (No. 14270), and eight from the Mineral Wells formation at Mineral Wells, Texas (No. 14286). In the Yale collections there is also one specimen labelled as having been collected from the Ochelata formation, below the Avant limestone near Skiatook, Oklahoma (SW. ¼, sec. 16, T. 22 N., R. 12 E.). The specimen has all the characters of the present species and yet one does not expect to find it so far above what seems to be its range. I am inclined to suspect something is wrong about the association of this single specimen and the label, and to hold that the specimen as of doubtful authority unless reinforced by further collecting.

Measurements of *Straparollus* (*Euomphalus*) *muricatus*

	A	B	C	D
Number of whorls	5½[a]	5½[a]	6[a]	6⅝[a]
Height	3.9 mm.	3.6 mm.	5.1[b] mm.	6.7 mm.
Width	13.8 mm.	13.0 mm.	18.0 mm.	21.5 mm.
Ratio of height to width	0.284	0.276	0.284	0.31

A. The holotype (Pl. 21, figs. 3*a–c*).
B. The topoparatype (Pl. 21, figs. 3*d–f*).
C. The largest topoparatye (not figured).
D. A paratype from Bell Plains, Texas (not figured).

[a] Allowing for the loss of the innermost whorls.
[b] Allowing for some mashing.

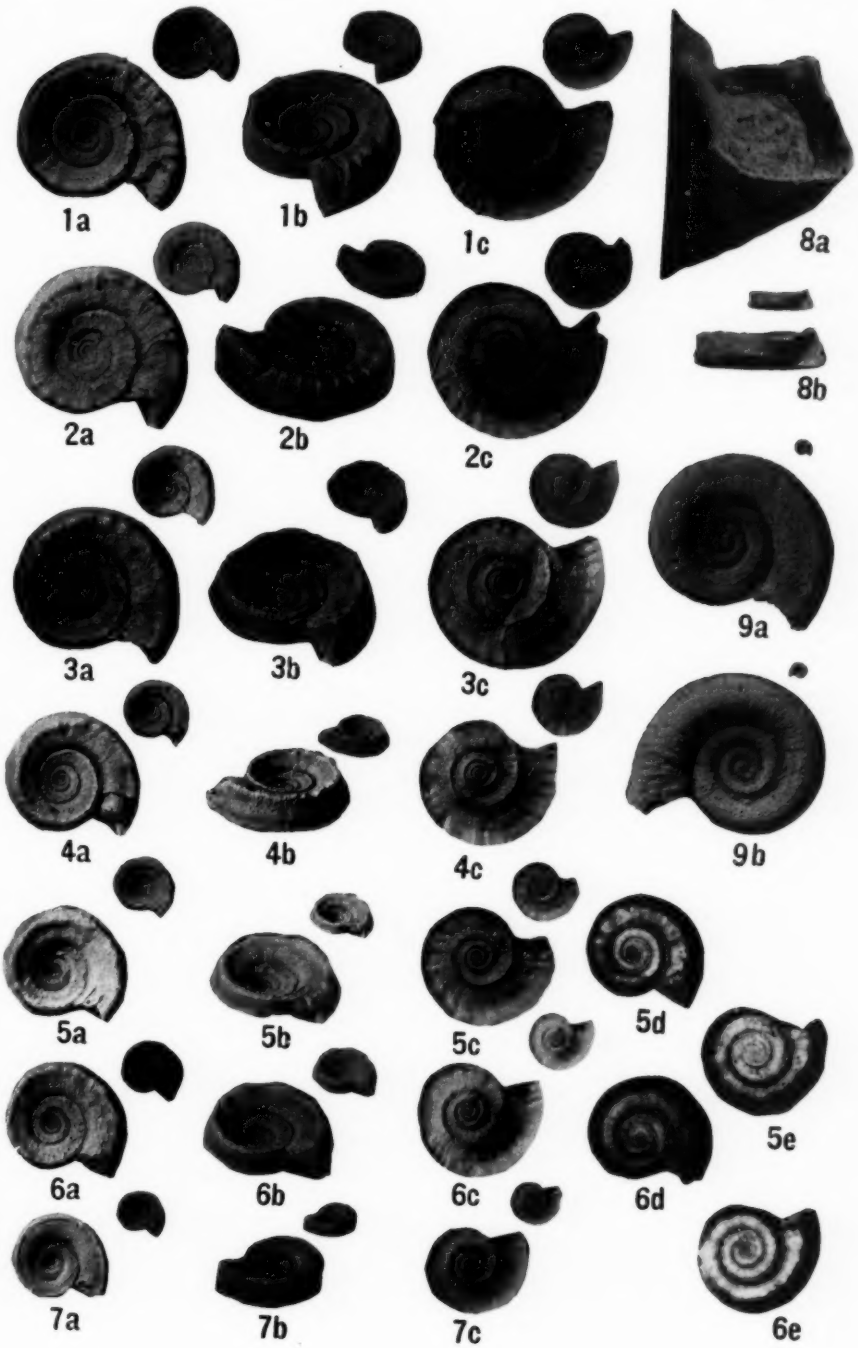
STRAPAROLLUS (EUOMPHALUS) MURICATUS
Knight, n. sp.

Plate 21, figures 3*a–f*, Plate 26, figure 3

Discoidal, planospirally coiled shells with the characters of the group of *E. catilloides;* coiling distinctly asymmetrical, the base being nearly flat, and the spire concave; whorl section externally

EXPLANATION OF PLATE 24

Straparollus (*Euomphalus*) *reedsi* Knight, n. sp. Page 159. All specimens from the St. Louis outlier. All figures ×2 except 8*a* and 9*a*, *b*. 1*a*, *b* and *c*, the holotype, apical and oblique apical views, respectively. 2*a*, *b*, *c* to 7*a*, *b*, *c* are apical, oblique apical and basal views of paratypes to show range of variation. 5*d*, *e* and 6*d*, *e* are photographed to show color pattern. Note the relatively less depressed spire, the deep sutures, the weakly developed upper carina and basal bourrelet, and especially the rounded whorl-base. 9*a* and *b* are apical and basal views, respectively, of a juvenile specimen (×10). Note the angulations beginning to find expression on the last half of the third whorl. 8*a* and *b* are introduced to show the somewhat spout-like channel at the upper angulation within the aperture. 8*a* is a view within the aperture, approximately ×10. The photograph has been retouched to eliminate two small breaks in the apertural margins. 8*b*, is an apertural view of the same specimen (×2) without retouching.



Knight, Pennsylvanian gastropods

trapezoidal; upper suture linear, not excavated; upper whorl-surface distinctly flat between the upper carina and the inner angular shoulder; upper carina sharply defined, smooth, wall-like, with few crenulations; outer whorl-face flat above and sloping outward to the bourrelet of the lower carina, which is extended outward in the plane of the base; lower whorl face nearly flat, a gentle sulcus near the bourrelet, and very gently convex toward the inner suture, basal sutures linear; growth lines on upper whorl-surface sweeping gently backward across the whorl, convex forward until close to the upper carina where they turn slightly forward, passing down across the outer whorl-face with a gentle concavity on the forward side, gently concave forward on the lower whorl-surface; pigmentation of outer shell layers concentrated at the carinae.

This species is close to *S.* (*E.*) *subrugosus* but it is broader, lower and flatter, and it is notably free from the rugosities on the carinae so strongly developed in that species. It is particularly characterized by its low, almost coin-like proportions, its flat base and by its sharply defined, even, wall-like upper carina.

All of the Yale specimens were derived from Lower Permian beds. The type locality is at Hooser, Kansas, and the type horizon is probably the Crouse limestone member of the Garrison shale,[6] from which there are six specimens (Peabody Museum No. 14271). In addition there are thirty-six specimens from the Foraker limestone near Cushing, Oklahoma (Peabody Museum No. 14272), and one specimen from the Belle Plains formation, at Belle Plains Texas (Peabody Museum No. 14273).

STRAPAROLLUS (EUOMPHALUS) SUBSULCATUS Knight, n. sp.

Plate 22, figures 1*a–f*

Discoidal, planospirally coiled shells with the characters of the subgenus and more particularly of the group of *Euomphalus catilloides;* discoidal, almost symmetrically coiled for first five whorls, with concave upper and lower surfaces, in the sixth whorl the spire becoming slightly elevated and the umbilicus deepened; whorl section externally trapezoidal, upper whorl-surface very slightly concave, nearly flat, sloping inward at about 20° from the horizontal; upper carina thin, sharp, not greatly extended, its edge fluted, rather than rugose; outer whorl-face gently arched for upper three-fourths, a well defined revolving sulcus occupying the lower fourth between the convex area and the lower carina; lower surface bounded on the outside by a rounded, finely rugose, carina which trends horizontally, very gently concave within the carina, sloping inward at an angle of about 25°; growth lines crossing the upper surface of whorl almost radially, but with very slight backward obliquity, passing straight over the upper carina with no sinus and down over the outer whorl-face very slightly convex above, very slightly concave below, and with a backward obliquity of about 12°, passing straight across the lower carina and with a slight concavity to the lower suture, pigmentation of the outer shell layer apparently uniform.

S. (*E.*) *subsulcatus* is readily distinguished from the other members of the group of *E. catilloides* by its larger size, the tendency for the spire to protrude after the fifth whorl, the fluted rather

[6] Oral communication, C. O. Dunbar.

Measurements of *Straparollus* (*Euomphalus*) *subsulcatus*

	A	B	C
Number of whorls	6[a]	5¼[a]	5½[a]
Height	7.5 mm.	6.5 mm.	6.0 mm.
Width	28 mm.	22.5 mm.	20.0 mm.
Ratio of height to width	0.27	0.27	0.30

A. A paratype, the largest specimen (Pl. 22, figs. 1*a–b*).
B. A paratype (Pl. 22, fig. 1*c*).
C. The holotype (Pl. 22, figs. 1*d–f*).

[a] Estimated on the assumption that the first two whorls are obscured.

than irregularly rugose edge to its upper carina, and by the distinct revolving sulcus on the lower part of the outer whorl face just above the lower carina.

There are in the Peabody Museum four specimens of this species from three different localities in Oklahoma.

Yale Peabody Museum No. 14274. Two specimens, including the holotype. Nowata shale, SW. corner sec. 15, T. 24 N., R. 15 E., north of Tulala, Oklahoma.

Yale Peabody Museum No. 14275. One specimen. "Shale above sandstone above Checkerboard (?) limestone," NW. ¼ sec. 29, T. 13 N., R. 10 E., Oklahoma.

Yale Peabody Museum No. 14276. One specimen. Wewoka-Holdenville formations undifferentiated, shaly limestone west of Bixby, Oklahoma.

STRAPAROLLUS (EUOMPHALUS) SUBQUADRATUS Meek and Worthen

Plate 22, figures 2*a–e;* Plate 26, figure 2

Straparollus (Euomphalus) subquadratus MEEK AND WORTHEN, *1870*, Acad. Nat. Sci. Philadelphia, Proc., p. 46; *1873*, Geol. Survey Illinois, vol. 5, p. 605, pl. 29, figs. 12*a–c*, 13*a c*, Pennsylvanian, Montgomery County, Illinois.

? *Straparollus subquadratus* (Meek and Worthen), KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 162, Pennsylvanian, Kansas City, Missouri, not *Euomphalus subquadratus* of Herrick, *1877*, nor White, *1891*, nor Smith, *1897*.

Discoidal, planospirally coiled shells with the characters of the subgenus and of the group of *E. catilloides*, though within the group it is the most aberrant species known; coiling somewhat asymmetrical the umbilicus being somewhat deeper than the concave spire; whorl section trapezoidal externally, very much broader on the outside; upper whorl-surface somewhat concave, surrounded by an upper carina capped with striking rugosities; outer whorl-face gently convex, a distinct, sharp, raised lira passing around it about one-third the distance from the top, lower angulation without a well marked carina though the angulation is prominent and rather sharp, whorl base gently convex on outer half, a revolving depression about midway to the suture shallow, but distinct; growth lines on the upper surface passing from the suture to the crest of the upper carinae slightly convex and oblique for the

Measurements of *Straparollus (Euomphalus) subquadratus*

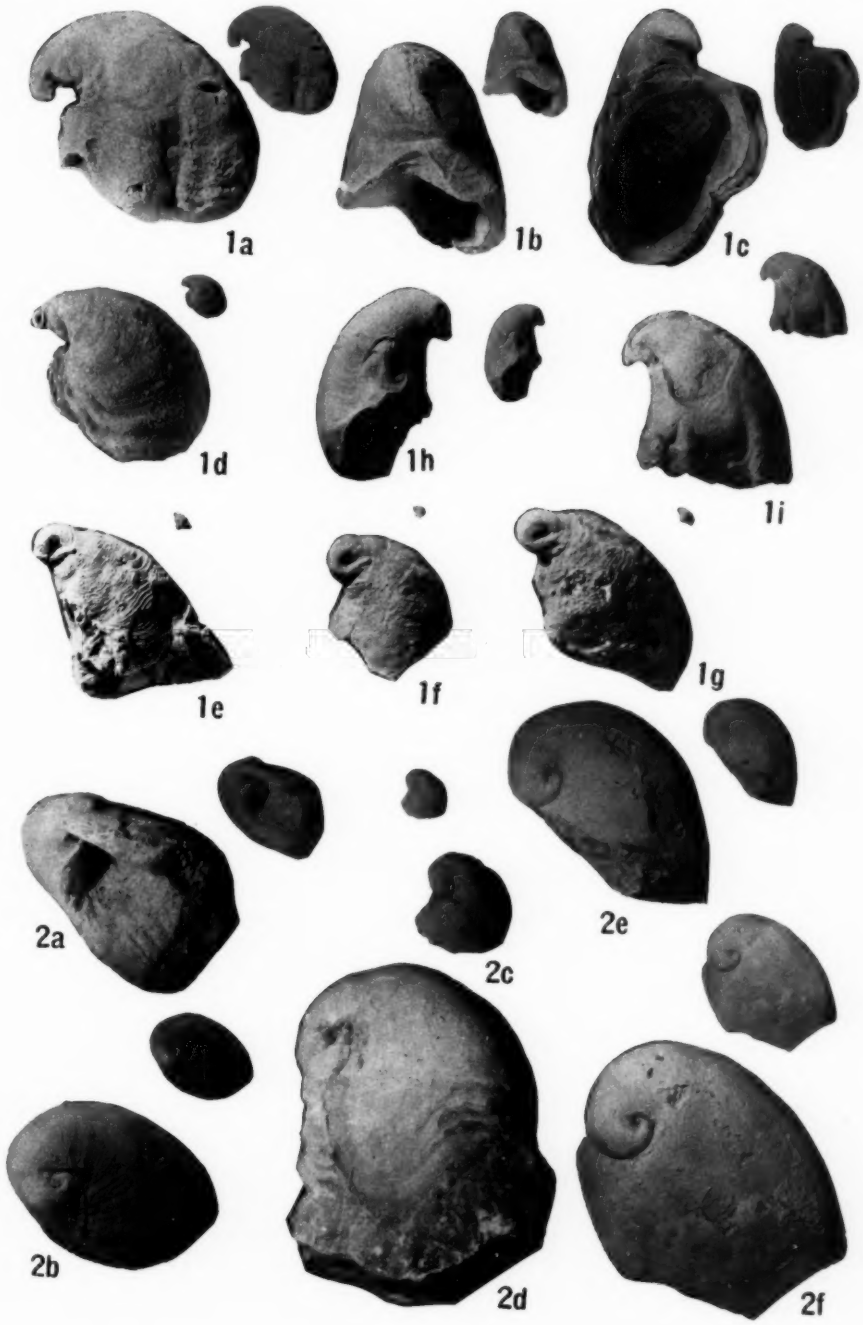
	A	B
Number of whorls	6¼	5¾
Height	10.0 mm.	8.0 mm.
Width	24.0 mm.	19.0 mm.
Ratio of height to width	0.42	0.42

A. The cyrioplesiotype (Pl. 22, figs. 2*c–e*).
B. A plesiotype (Pl. 22, fig. 2*a*).

EXPLANATION OF PLATE 25

FIGS. 1*a–i*—*Orthonychia parva* (Swallow). Page 163. *a*, *b* and *c*, Three views of the largest specimen from the St. Louis outlier, (×2). Note the gerontic thickening of the margins. *d*, A small specimen from the St. Louis outlier, (×4). *e*, A juvenile specimen, (×10). Note sharp, irregular transverse lirae. *f* and *g*, Tips broken off larger specimens, (×10). The transverse lirae seem to have been destroyed by abrasion, as they are on most well grown specimens. Note curious vermiform nuclei on *d*, *e*, *f* and *g*. *h*, A specimen from Eudora shale and *i*, one from the Quindaro shale in Kansas, (×2). The plications and more irregular apertural margins of these last two specimens as compared to the preceding ones is thought to reflect only differences in the crinoids to which they were attached in life.

2*a–f*—*Helictostylus girtyi* Newell mss., n. sp. Page 164. All figures ×2. All specimens from the Stoner limestone at Fredonia, Kansas. *a* and *b*, The holotype. Note particularly the revolving columellar fold, shown in the apertural view. *c*, A young individual to show closely coiled nucleus. *d*, *e* and *f*, Three paratypes. *d* shows well the wide sinus in the outer lip.



Knight, Pennsylvanian gastropods

first two-thirds of the distance, then turning slightly forward with a slight concavity, on the outer whorl face above the sharp revolving thread swinging strongly forward from the crest of the carina with a distinctly concave front, then nearly straight down across the two-thirds of the whorl face below the revolving thread to the lower angulation and with a very slight obliquity backward; on the lower whorl face they are slightly concave; outer shell layer seemingly strongly and uniformly pigmented.

This very striking species hardly needs comparison. It is characterized by the almost triangular whorl section, the strongly rugose upper carina and above all by the unique revolving lira on the upper part of the whorl-face, separating the face into two areas the lower with nearly straight, vertical growth-lines and the upper with strongly reclining, concave growth-lines. I have been unable to obtain the type of this species but it hardly seems necessary since not only are Meek and Worthen's descriptions and figure excellent but the species itself is highly distinctive.

Family PLATYCERATIDAE Hall, 1859

Genus ORTHONYCHIA Hall, 1843

ORTHONYCHIA PARVA (Swallow)

Plate 25, figures 1*a–i;* Plate 26, figures 1*a–b*

Capulus parva SWALLOW, *1858*, St. Louis Acad. Sci., Trans. vol. 1, p. 205, Pennsylvanian, Valley of the Verdigris, Kansas.

Platyceras nebrascensis MEEK, *1872*, U. S. Geol. Survey Nebraska, Final Rept., p. 227, pl. 4, fig. 15*a, b*. Pennsylvanian, Nebraska City, Nebraska.

Platyceras nebrascense Meek, WHITE, *1877*, U. S. Geol. Survey, W. 100th Merid., 4, p. 159, pl. 12, figs. 5*a–d*, Pennsylvanian, near Santa Fe, New Mexico; *1884*, Indiana Dept. Geol. and Nat. Hist., 13th Ann. Rept., pt. 2, p. 159, pl. 32, figs. 15, 16. Pennsylvanian, Indiana.

Capulus parvus (Swallow), KEYES, *1890*, Acad. Nat. Sci. Philadelphia, Proc., p. 177, pl. 2, figs. 14*a–c; 1895*, Missouri Geol. Survey, vol. 5, pt. 2, p. 180, pl. 54, figs. 5*a–b*, Pennsylvanian, Kansas City, Missouri. (Figures Swallow's holotype.)

Platyceras parvum (Swallow), GIRTY, *1903*, U. S. Geol Survey, Prof. Paper, 16, p. 461, pl. 10, figs. 1, 1*a*, 2, 2*a*. Hermosa formation, Pennsylvanian, San Juan region, Colorado. MORGAN, *1924*, Oklahoma Bur. Geology, Bull. 2, pl. 49, fig. 16, Boggy formation, Pennsylvanian, N. cen. sec. 35, T. 2 N., R. 6 E., Stonewall quadrangle, Oklahoma.

Measurements of *Orthonychia parva*

	A	B
Length along anterior curve, anterior apertural edge to apex	29.0 mm.	22.0 mm.
Diameter of aperture, longitudinal	15.0 mm.	10.5 mm.
Diameter of aperture, transverse	12.0 mm.	7.0 mm.

A. A large specimen from the St. Louis outlier (Pl. 25, figs. 1*a–c*).
B. A large specimen from Kansas (Pl. 25, fig. 1*i*).

The specimens before me are all in the collections of the Peabody Museum at Yale.

One specimen from the Wewoka formation (Pennsylvanian) at Okmulgee, Oklahoma. Yale Peabody Museum No. 14277.

Two specimens and some fragments from the Hoxbar formation, Pennsylvanian, 6 miles southwest of Ardmore, Oklahoma. Yale Peabody Museum No. 14278.

Three specimens and a fragment in two collections from the *Uddenites* zone (Pennsylvanian? or Permian?), at Wolfcamp, 12 miles northeast of Marathon, Texas. Yale Peabody Museum No. 14279.

Hooked, claw-like shells with the characters of the genus; nucleus a narrow vermiform hook of one open revolution, smooth, unpigmented and with a distinct anterior notch; shell expanding rapidly immediately the neanic stage is reached so that when the nucleus is destroyed the apex of the mature shell may appear bluntly rounded; very minute irregular transverse lirae also appear at the same stage and probably continue through life though commonly obliterated by abrasion; neanic and ephebic stages continue as a rapidly expanding, curved and sometimes slightly twisted cone; aperture suboval, longer than wide;

apertural margins irregular through adaptation to contours of the substratum (the calyx or tegmen of a crinoid) generally a broad sinus in front and behind; general surface influenced by growth of apertural margins, relatively smooth with irregular growth lines only or with strong longitudinal folds, or any intermediate stage; shell pigmented, sometimes vaguely banded.

None of my specimens show any trace of muscle scars.

Specific differences in platyceratids may be very difficult to recognize and *O. parva* as here constituted on the basis of the literature and of the specimens before me may include more than a single species. One hardly knows what characters are good for discrimination of forms that are individually so profoundly influenced by the accidents of their individual choice of station. Certainly characters such as plicae, that are attributable to the individual's substratum,

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EXPLANATION OF PLATE 26

FIGS. 1*a–b*—*Orthonychia parva* (Swallow). Page 163. Thin section of small specimen apex above Approximately ×8. Section cut approximately as shown in diagram 1*b*, where the dotted line indicates the plane of the section. Specimen from the top of the Labette shale in the St. Louis outlier.

2—*Straparollus* (*Euomphalus*) *subquadratus* Meek and Worthen. Page 162. Polished section of whorl of a large individual, ×2. Note the extreme development of the lower angulation characteristic of this species. Specimen from the Hoxbar formation, near Ardmore, Oklahoma.

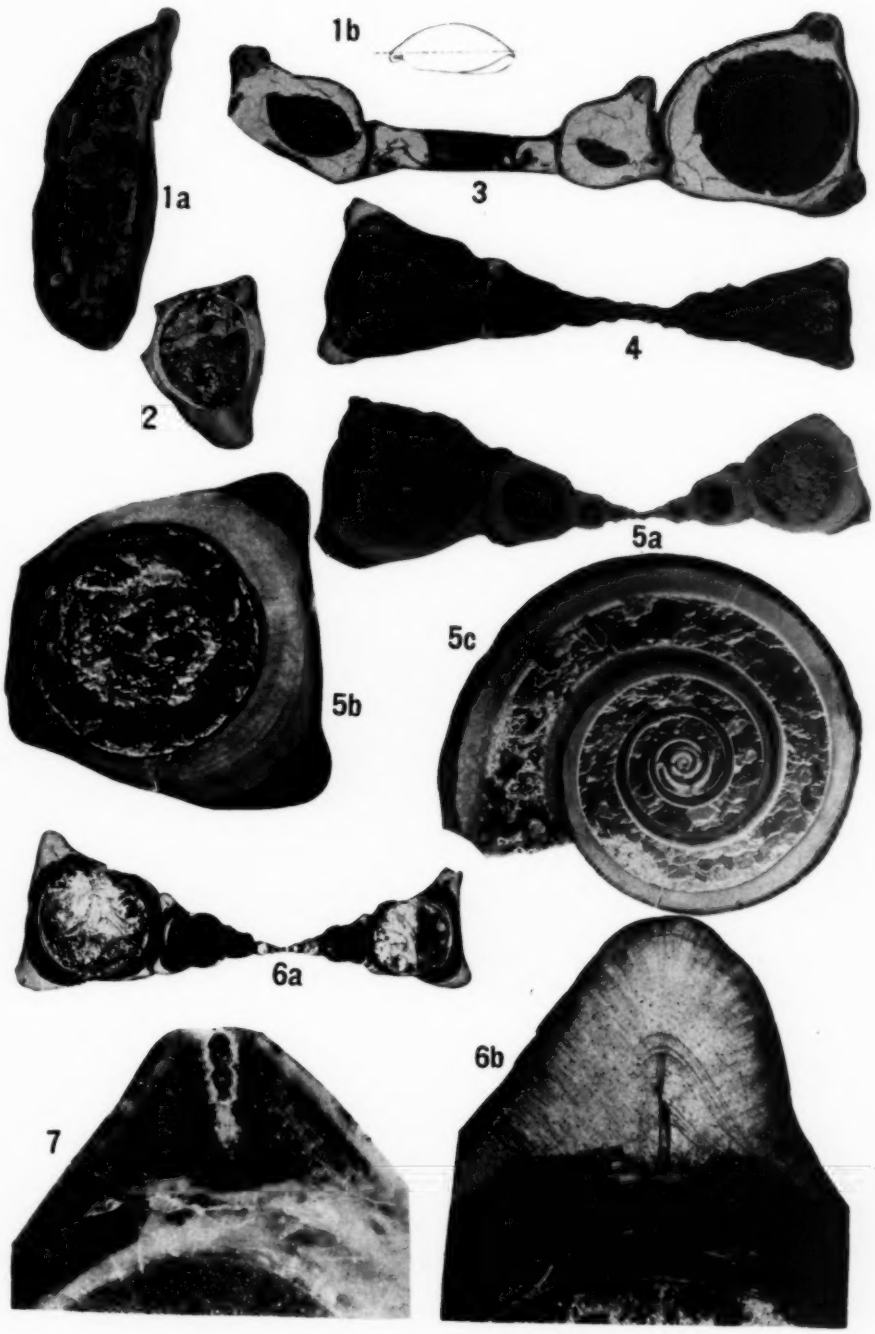
3—*Straparollus* (*Euomphalus*) *muricatus* Knight, n. sp. Page 160. Transverse section of a topoparatype, approximately ×6. The shell material is badly recrystallized except in its outermost parts in the larger volutions, and the lower left-hand corner is broken away. By transmitted light.

4—*Straparollus* (*Euomphalus*) *catilloides* (Conrad). Page 155. Transverse section, approximately ×6. By transmitted light. Specimen from the Hoxbar formation, near Ardmore, Oklahoma. Note the symmetrically converging upper and lower surfaces.

5*a–c*—*Straparollus* (*Euomphalus*) *reedsi* Knight, n. sp. Page 159. All dark field illumination. All specimens from the top of the Labette shale, St. Louis outlier. *a*, Transverse section, approximately ×10. The upper carinae, and the lower, right-hand, lower carina are partly broken away. *b*, Transverse section of final whorl of another specimen, approximately ×15. Note outer, prismatic layer, strongly pigmented, thickened to form the carinae at the angulations; note also the trace of the channel in the upper angulation as shown in the shell-structure. *c*, An horizontal section, the plane of the section passing near the base. Note the dark, pigmented outer layer, and the four septa, shutting off successive portions of the first three whorls.

6*a–b*—*Straparollus* (*Euomphalus*) *subrugosus* Meek and Worthen. Page 157. *a*, Transverse section, approximately ×6, of a specimen from the Jacksboro limestone, near Graham, Texas. Transmitted light. The black areas are replacements of the original shell, mostly of the inner layers, by limonitic material. Note the high, strongly developed carinae. *b*, Section of the carina shown at the upper left of the preceding figure, approximately ×45. Note the course of the prisms in the outer layer and of the incremental lamellae of both layers. The latter delineate transverse sections of the apertural channel at various stages. The inner layers, and the inner margin of the outer layer, are partially obscured by alteration.

7—*Straparollus* (*Euomphalus*) *plummeri* Knight, n. sp. Page 152. Transverse, polished section of the upper angulation of a moderately large specimen from Jacksboro limestone, near Graham, Texas. Approximately ×10. The oblique surface to the left is the flat upper, whorl surface. The inner shell layers and some of the outer have, in part, recrystallized, and chemical alteration has proceeded along the line of weakness formed by the trace of the trough of the apertural channel. Note the course of the incremental lamellae and, more faintly in this specimen, the prisms normal to their surfaces. The former delineate transverse sections of the apertural channel at various stages.



Knight, Pennsylvanian gastropods

are not specific, however conspicuous they are, unless we are ready to assume that each platyceratid species attached itself to a single crinoid species. One seems to be limited for specific characters to details of ornamentation that are independent of the substratum and to general form. Even the latter may be somewhat influenced by the position of the gastropod on its host, and by differences in the quantity of food supplied by the host.

The described species of American Pennsylvanian *Orthonychia* seem to be all about of a size, to have the same form, and with the exception of the pustulose or spine-bearing *O. spinigera* (Worthen), the same ornamentation.

In the two collections before me, many, but not all, of the specimens from the Missouri group of Kansas have strong irregular plications as shown in Plate 25, figure 1*i*. None of my specimens from the Des Moines group of the St. Louis outlier have such plications. Yet the plication on the Kansas specimens seem to be the only differences and many of the Kansas specimens are as gently undulating as those from lower in the section further east. I cannot hold the two as distinct species on the basis of what seems to be a fortuitous character dependent on the species of crinoid selected as a host. It cannot be denied, however, that such a character may have stratigraphic utility though the character is an expression of the crinoid rather than the gastropod fauna.

From the St. Louis Pennsylvanian outlier I have thirty-six specimens, thirty-five from Zone G at the top of the Labette shale at Locality 43, and one, a steinkern, from the lower Fort Scott limestone at Locality 21. These bear Yale Peabody Museum Nos. 14283, and 14284 respectively.

Dr. Norman D. Newell has loaned me eleven specimens as follows.

Five specimens, Quindaro shale, Boyn's quarry, NE. of Welborne, Wyandotte County, Kansas.

Three specimens, Eudora shale, center west side sec. 36, T. 27 S., R. 16 E., Kansas.

One specimen, Eudora-Stoner, just west of NE. cor., T. 23 S., R. 17 E., Kansas.

One specimen, Hickory Creek shale, center west side, sec. 8, T. 27 S., R. 17 E., Kansas.

One specimen, Hickory Creek shale, brick pit, 3 miles SW. of Chanute, Kansas.

One specimen, top of Avant limestone, Quarry 2 miles SE. of Avant, Oklahoma.

Genus HELICTOSTYLUS Knight, n. gen.

HELICTOSTYLUS GIRTYI Newell, mss.
Plate 25, figures 2*a–f*

Widely explanate, coiled gastropods of not more than three whorls with the characters of the genus; nucleus simple, dextral, of about one whorl, set off from succeeding stages by a rather sudden increase in the rate of expansion; succeeding whorls, increasing rapidly in size, smooth, ornamented only with fine, somewhat irregular lines of growth; upper lip thin, reaching far to the left of the spire onto the parietal wall and extending horizontally far to the right; outer lip thin, sharply curved, with a broad sinus; lower lip thin, sweepingly curved; columellar lip thick with a sharp margin within which it is flattened; sharp margin curving spirally inward toward the apex; outer, parietal surface also curving spirally inward; shell highly lamellar, probably with two layers. Coloring, if any, unknown.

This remarkable and interesting species, the first of the genus to be described from American Pennsylvanian strata, is not to be confused with *Naticopsis torta* Meek, based on a naticopsid steinkern and sometimes referred to

Measurements of *Helictostylus girtyi*	A	B
Number of whorls	2¼	2½
Height	15.0 mm. ±	10.0 mm.
Width	20.0 mm. ±	23.0 mm. ±

A. The holotype, a half-grown specimen (Pl. 25, figs. 1*a–b*).
B. A paratype (Pl. 25, fig. 2*f*).

Platyceras or with any of the Pennsylvanian explanate naticopsids erroneously referred to *Strophostylus* in the past. Its irregularities of growth mark it definitely as one of the Platyceratidae and the revolving columellar fold as a true member of the genus *Helictostylus*.

Doctor Newell has been generous enough to lend me for the purpose of this paper all of his material on this species. It consists of thirty-one specimens, all from the Stoner limestone, at the Cement Plant at Fredonia, Kansas. The specimens are preserved in a white crystalline limestone which is almost a coquina. The shell material itself is softer than the matrix and somewhat chalky and hence most specimens are badly exfoliated.

The types will be deposited in the University of Kansas collections.

Dr. Newell's manuscript description reads. in part, as follows:—

In general form the shell at hand recalls *Platyceras* or the shells commonly classified as *Strophostylus*. The largest of the thirty specimens measures 25 mm. in length as measured through the outer margin of the aperture. The shell consists of two to two and one-half tightly coiled, rapidly expanding volutions of which the last constitutes by far the greater part of the shell. The apical part of the shell is depressed so that there is scarcely a distinguishable spire. At a shell length of 4 mm. and one and one-half volutions the form is distinctly platyceratid. At this stage there occurs a slight constriction followed by abrupt expansion of the aperture so that the nucleus of adult shells is distinctly set off from the latter part of the shell. The inner lip of the aperture at mature stages is thickened to form a sort of columella with a flattened margin. The growth lines are sinuous and irregular apparently at all growth stages suggesting that the organism was attached throughout much of its life. The whorl section and aperture in large specimens is more or less strongly depressed in a direction parallel to the axis so that the form is elliptical. Commonly old specimens display a deep and broad sinus at the outer margin of the lip. The margin of the lip in such specimens is generally quite irregular. A thin inductura covers the surface of the inner lip.

References

1. Knight, J. B., The gastropods of the St. Louis, Missouri, Pennsylvanian outlier.
   a. The Pseudozygopleurinae. *Jour. Paleontology*, vol. 4, Supplement 1, pp. 1–88, 1930.
   b. *Aclisina* and *Streptacis*. *Jour. Paleontology*, vol. 5, pp. 1–15, 1931.
   c. The Subulitidae. *Jour. Paleontology*, vol. 5, pp. 177–229, 1931.
   d. The Pseudomelaniidae. *Jour. Paleontology*, vol. 6, pp. 189–202, 1932.
   e. The Trocho-turbinidae. *Jour. Paleontology*, vol. 7, pp. 30–58, 1933.
   f. The Neritidae. *Jour. Paleontology*, vol. 7, pp. 359-392, 1933.
2. Knight, J. B., The location and areal extent of the Saint Louis Pennsylvanian outlier.
   Pt. 1, *Am. Jour. Sci.*, (5), vol. 25, pp. 25–48, 1933.
   Pt. 2, *Loc. cit.*, pp. 166–178, 1933.
3. Ulrich, E. O., and Scofield, W. H., The Lower Silurian gastropods of Minnesota: Geology of Minnesota, vol. 3, pt. 2 of the final report, 1897.
4. Montfort, D. de, Conchyologie Systematique, vol. 2, 1810.
5. Meek, F. B., and Worthen, A. H. *Illinois Geol. Survey.*
   a. Vol. 2, 1866.
   b. Vol. 5, 1873.
6. Sowerby, J., Mineral Conchology of Great Britain, vol. 1, 1812.
7. Koninck, L. G. de., Faune du Calcaire Carbonifère de la Belgique. Pt. 3, Gastéropodes: *Ann. du Mus. Roy. d'Hist. Nat. de Belg., sér. paléont.*, T. 6.
8. Conrad, T. A., Third Annual Report on The Paleontological Department of the Survey: *New York Geol. Survey*, Ann. Rept. 4, pp. 199–207, 1840.
9. Miller, S. A., North American Geology and Paleontology, 1889.
10. Phillips, J., Paleozoic fossils of Cornwall, Devon and West Somerset, 1841.
11. Fisher, G., Adversaria zoologica, pt. 3: *Mem. de la Soc. Imp. des Naturalistes de Moscou*, vol. 6, 1823.
12. Fahrenkohl, *Bull. de Soc. Imp. des Naturalistes de Moscou*, 1844.
13. Hall, J., Geology of New York, Part 4, 1843.
14. Hall, J., Descriptions of new species of fossils, etc.: Continuation of Appendix C of the 14th Ann. Report of the Regents of the State Cabinet, 1861.
15. Bassler, R. S., Bibliographic index of American Ordovician and Silurian fossils: *U. S. Nat. Mus., Bull.* 92., 1915.
16. Hall, J., Paleontology of New York, 3, 1859.
17. Fisher, P., Manuel de Conchyliologie. 1885.

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 2, PP. 167-168, PL. 27, JUNE, 1934

A NEW SPECIES OF CALCISPONGE FROM THE BUDA LIMESTONE OF CENTRAL TEXAS

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ABSTRACT

The species *Verticillites budaensis* from the Lower Cretaceous of Texas is described. This genus of calcisponges occurs in the Cretaceous of Europe but has not previously been recorded in North America.

Research on the coelenterates and sponges of the Buda limestone of central Texas has brought to light a new species of *Verticillites*, a genus of the calcareous sponges confined to the Cretaceous. This is the first record of this genus in North America and its similarity to species of the uppermost Cretaceous of Europe is striking.

All of the specimens were collected by Dr. F. L. Whitney of the Department of Geology of the University of Texas.

DESCRIPTION OF SPECIES

Family VERTICILLITIDAE Steinmann, 1882

Order SYCONES Haeckel

Genus VERTICILLITES Defrance, 1828

Type species. *Verticillites cretaceus* Defrance, 1828, Danian, France.

VERTICILLITES BUDAENSIS Wells, n. sp.

Plate 27, figures 1–5

The sponge is small, club-shaped or cylindrical, the individuals tending to be separate or in groups of two or three, rather than to form bushy clumps. The type specimen consists of two globose individuals attached by a common base, having a height of 24 mm., the larger individual measuring 23 mm. in maximum diameter and the smaller 17 mm. Other specimens, more elongated and more cylindrical than the type, measure 20 mm. in height and 9 mm. in diameter. The sides of the sponge are marked by constrictions of the walls produced by the successive addition of chambers or segments. This feature is not as marked in the globose as in the cylindrical forms. The summit is convex or arched with the osculum occupying a slight depression

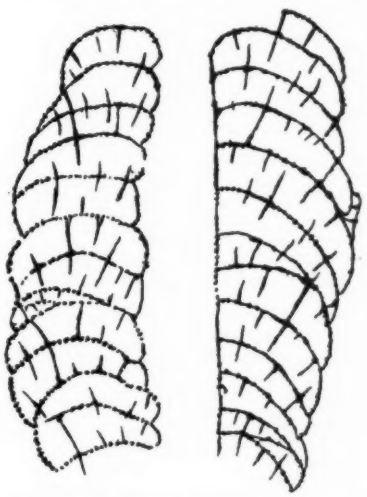


FIG. 1. Diagram of vertical section of *Verticillites budaensis* showing skeletal apparatus (±×4).

in the center. In the type the opening of the osculum measures 3.5 mm. in diameter; in the others it is but 1.5 mm., corresponding to the relatively smaller diameter of the segment upon which it is located. The interior is traversed by the cloacal tube which extends through the vertical axis of the sponge downwards from the osculum and which is connected to the segments by numerous openings through its walls. The walls are everywhere perforated by fine circular or oval openings whose diameters average 0.15 mm., and, as seen in cross-section, they are supported and braced by thin columns so that the floor of each segment forms the roof of the one just below it. The thickness of the outer walls and segmental walls averages 0.15 mm. The spicules composing the fibers of which the walls are formed cannot be distinguished.

Nine specimens of this species have been examined. As a whole they appear to form two intergrading groups distinguished by the general shape of the individuals. The first group, which contains six of the specimens, includes the type specimen and others which are relatively short and globose with a maximum diameter nearly as great as their height. In these forms the number of chambers seen in a vertical section number from ten to twelve in a space of 10 mm. The second group includes the cylindrical specimens the chambers of which do not increase in size upwards, and in a section there are from six to nine chambers in a space of 10 mm. The two groups completely intergrade and it is unlikely that more than one species is involved.

This species is closely related to the type species as described and figured by Steinmann.[1] His figures show a globose form like those in the first group mentioned above in which there are from seven to eight chambers in a space of 10 mm., and with a cloacal tube averaging 4 mm. in diameter. The wall apertures average 0.15 mm. in diameter.

Ravn[2] has described under the name *Barroisia faxensis* a species of *Verticillites* from the Danian of Faxöe which has an elongate cylindrical form with six to seven chambers in 10 mm. and a cloacal tube measuring about 2 mm. in diameter. Judging from his figures, the structure of this species is close to that of the second group of the Buda species. His reference to *Barroisia* is probably incorrect, because in that genus the floors of the chambers are thick and traversed by well-defined tubes and the walls are not supported by columns, as in *Verticillites*.

V. budaensis is relatively easy to recognize even in a fragmentary condition due to the characteristic chambered structure seen in vertical section.

The species occurs in the lower beds of the Buda limestone along Shoal Creek in Austin; at Round Rock, Williamson County; and on the first creek south of Manchaca, Travis County, Texas. All specimens are in the collections of the Department of Geology, University of Texas.

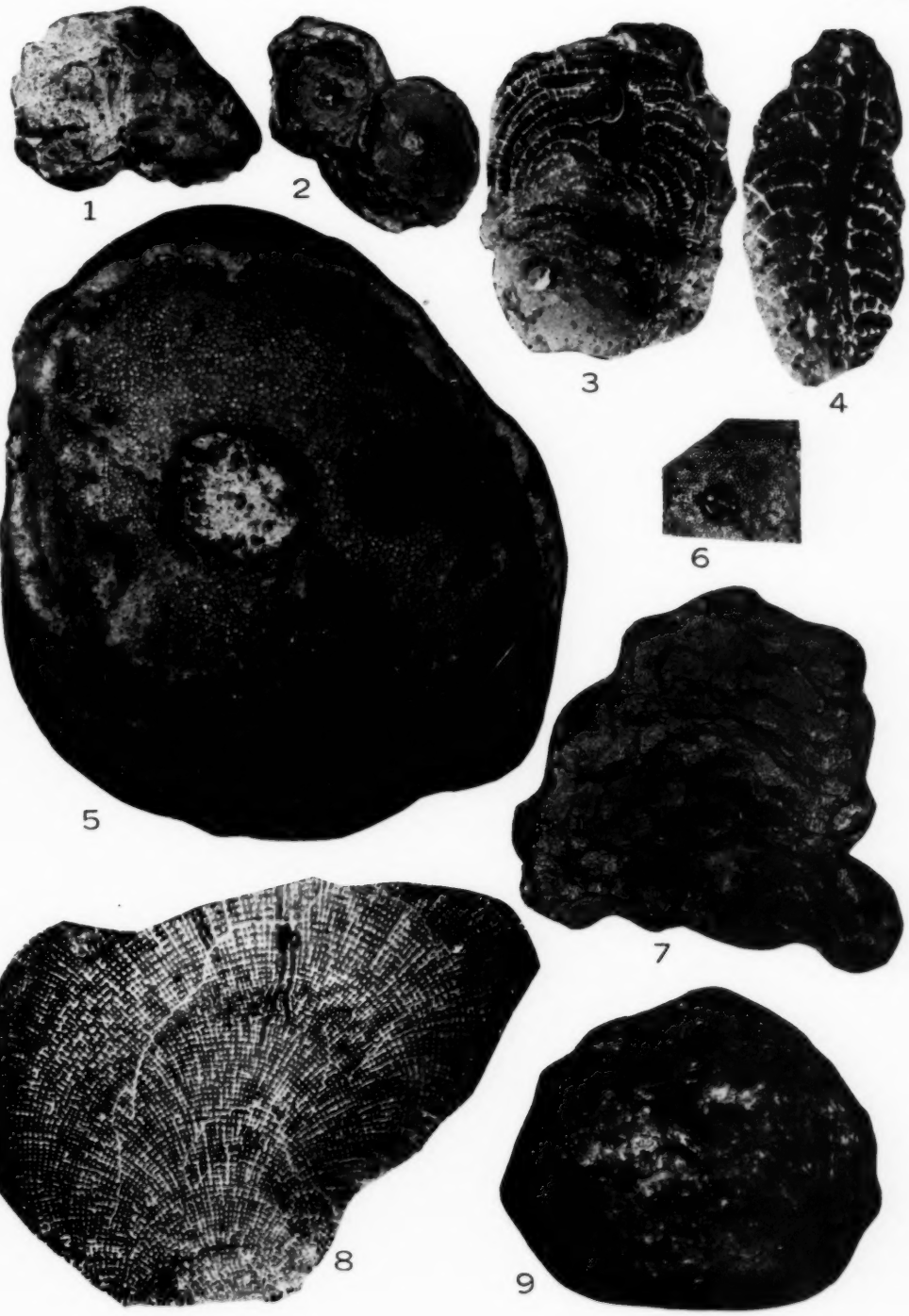
[1] Steinmann, G., Pharetronen-studien: *Neues Jahrb.*, vol. 2, pp. 174–175, pl. 8, fig. 2, 1882.

[2] Ravn, J. P. J., *Dansk geol. Forening.*, no. 5, p. 28, pl. 1, figs. 4, 5, 1899.

EXPLANATION OF PLATE 27

FIGS. 1–5—*Verticillites budaensis* Wells, n. sp. 1, Cotype, side view, ×1. 2, Same, showing upper surface with oscula, ×1. 3, Vertical thin section of a paratype, first group, ×2.4. 4, Vertical thin section of a paratype, second group, ×2.4. 5, Upper surface of a larger individual, a cotype, ×4. (p. 167)

6–9—*Actinostromaria dehorneae* Wells, n. sp. 6, Transverse thin section across several astrorhizal tubes, type specimen, ×2.4. 7, A massive encrusting colony, paratype, ×1. 8, Longitudinal thin section of type specimen, ×3.7. 9, A nodular colony, paratype, ×1. (p. 169)



Wells, Cretaceous sponge and stromatoporoid

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 2, PP. 169-170, PL. 27, JUNE 1934

A NEW SPECIES OF STROMATOPOROID FROM THE BUDA LIMESTONE OF CENTRAL TEXAS

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ABSTRACT

The stromatoporoid *Actinostromaria dehorneae* is described from the Lower Cretaceous of Texas.

In the course of a study of the corals of the Buda limestone of central Texas several specimens from the lower beds of that formation were found to belong to the stromatoporoids, that obscure group of hydrozoans common in the Paleozoic but rather rare in the Mesozoic rocks. Most of the specimens were collected by Dr. F. L. Whitney of the Department of Geology of the University of Texas and were turned over to the author along with the hexacorals for description. One specimen, collected at Round Rock by C. Fletcher, has been deposited in the Natural Museum, whereas the type and paratype material are in the collections of the University of Texas.

It is interesting to note the presence of a species of *Actinostromaria* in America in beds of nearly the same age as those in which the type species is found in France.

DESCRIPTION OF SPECIES

Family ACTINOSTROMATIDAE Nicholson, 1886

Genus ACTINOSTROMARIA Haug, 1909

Actinostromaria MUNIER-CHALMAS (Ms.).—TORNQUIST, *1901*, Mesoz. Stromatoporiden. Abh. Preuss. Akad. Wiss , vol. 47, p. 1116. (*nom. nud.*)—HAUG, *1909*, Traité de Géol., vol. 2, pl. 97. (no text.)—DEHORNE, *1920*, Mém. Carte géol. France, p. 64.—HAUG, *1922*, Traité de Géol., vol. 2, pl. 97.—KUHN, *1928*, Foss. Cat. pars 36, p. 76.

Like *Actinostroma*, but the radial pillars are more regular and robust. The astrorhizae, very largely developed, are superposed one upon the other, producing in vertical sections well individualized central astrorhizal tubes; the radial pillars which limit them tend to fuse and form walls. The surface of the colonies, lightly undulating, is covered by numerous mamelons. Colonies nodular and massive, without a basal epitheca, sometimes encrusting or lamellar, but never dendroid.

The type species is *Actinostromaria stellata* Haug, 1909, of the Cenomanian at Bouches-du-Rhône.

At present the genus is known only from the Cretaceous and at the type locality at Île Madame *A. stellata* forms veritable reefs.

ACTINOSTROMARIA DEHORNEAE Wells, n. sp.
Plate 27, figures 6–9

Colonies massive-encrusting or forming small nodular free subspherical masses. The surface, which is rarely well preserved, is undulating and marked by the astrorhizae, which form star-shaped openings with numerous ramifications or radiating canals. The colony increases by the successive addition of concentric

layers or latilaminae which are usually distinct in weathered specimens and which average about 4 mm. in thickness. The skeletal elements consist of two structures—rodlike pillars which extend vertically and may pass through several latilaminae and which are united laterally at regular intervals by cross bars which may form horizontal laminae so that the whole assembly has a regularly reticulated structure. The astrorhizae are usually very small when seen in transverse section and are irregularly spaced from 1 to 3 mm. apart, averaging about 1 mm. in diameter, exclusive of their ramifications. Around them there is a tendency for the skeletal elements to fuse and form a poorly-defined wall. The skeletal elements number about six in a space of 1 mm.

The ramifications of the astrorhizae in this species are not as extensive as in the type species *A. stellata*[1] and there is more of a tendency for the skeletal elements within the limits of the astrorhizae to assume a regularly radiating arrangement. Unfortunately the upper surface of the colonies is not well shown in any of the specimens and the presence or absence of mamelons, or boss-like elevations, cannot be determined.

This species occurs in the lower beds of the Buda limestone along Shoal Creek, in Austin; near Manchaca, Travis County; and at Round Rock, Williamson County, Texas.

[1] Dehorne, Y., Les Stromatoporoidés des Terrains Secondaires: *Mém. Carte géol. France*, p. 65; pl. 1, 2; pl. 3, figs. 2–4; pl. 4, figs. 2, 7, 8; pl. 5, fig. 9; pl. 6, fig. 5; pl. 9, figs. 1, 2, 7; pl. 10, figs. 1–3; pl. 11, figs. 1, 2, 1920.

Measurements of *Actinostromaria dehorneae*

Specimen	*Height*	*Diameter*	*Form*
1 (Type)	19 mm.	22 mm.	Nodular
2 (Paratype)	41 mm.	55 mm.	Nodular
3 (Paratype)	50 mm.	52 mm.	Massive-encrusting

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 2, PP. 171-185, PL. 28, JUNE, 1934

THE CEPHALOPOD FAUNA OF THE PENNSYLVANIAN NELLIE BLY FORMATION OF OKLAHOMA

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ABSTRACT

The Nellie Bly formation, a member of the Kansas City group, contains a prolific fauna which is clearly a recurrent Wewoka fauna. However, the ammonoids are markedly different from those of the Wewoka and they indicate that the Nellie Bly is to be correlated with one of the upper members of the Gaptank formation of western Texas and with the Palo Pinto limestone of north-central Texas. All of the cephalopod species known from the Nellie Bly are described and illustrated, and a discussion of the genera *Shumardites* and *Pericleites* [=*Proshumardites*] is included. Five new species and one new genus of ammonoids are established.

The Nellie Bly is a marine formation that occurs in northeastern Oklahoma and the adjacent part of Kansas. According to Gould[1] and Ohern[2] it consists of "alternating shales and hard, gray sandstones," and it ranges in thickness "from 15 feet on the Kansas [-Oklahoma] line to 200 feet in southeastern Osage County," Oklahoma—south of there it merges with the Francis formation. It lies conformably between the Hogshooter limestone=Lost City limestone below and the Dewey limestone above, a stratigraphic position which proves that it belongs in the Kansas City group. According to Condra, Moore, and Dunbar[3] the Nellie Bly is the correlative of the Cherryvale shale of Kansas, Missouri, and Nebraska.

Although the Nellie Bly contains a well-preserved, prolific fauna, in so far as we have been able to ascertain, not a single species has been described or listed from it. The fauna is dominantly molluscan, but corals, echinoids, crinoids, bryozoans, brachiopods, and trilobites also are represented. Most of the species occurring in this formation are strikingly similar to those that occur in the Wewoka and the fauna is clearly a recurrent Wewoka fauna. In fact, forms which are either identical or very closely similar to the following Wewoka species occur in the Nellie Bly:

Corals
Lophophyllum profundum (M.-E. and H.)
Michelinia eugeneae White
Crinoids
Delocrinus? sp.
Conularids
Conularia crustula White

[1] Gould, C. N., Index to the stratigraphy of Oklahoma . . . : *Oklahoma Geol. Survey, Bull.* 35, p. 74, 1925.

[2] Ohern, D. W., unpublished manuscript quoted by Gould, op. cit.

[3] Condra, G. E., Moore, R. C., and Dunbar, C. O., *Nebraska Geol. Survey*, 2d ser., Bull. 5, table C, opp. p. 18, 1932.

Bryozoans
Fistulipora carbonaria Ulrich
Brachiopods
Lindstroemella patula (Girty)
Chonetes granulifer var. *armatus* Girty
Juresania nebrascensis (Owen)
Marginifera lasallensis (Worthen)
Marginifera splendens (Norwood and Pratten)
Wellerella tetrahedra Dunbar and Condra
Punctospirifer kentuckiensis (Shumard)
Neospirifer cameratus (Morton) s. 1.
Composita subtilita (Hall)
Cleiothyridina orbicularis (McChesney)
Pelecypods
Edmondia gibbosa (M'Coy)?
Nucula anodontoides Meek?
Nuculopsis ventricosa (Hall)
Leda bellistriata Stevens
Yoldia glabra Beede and Rogers
Astartella concentrica (Conrad)
Gastropods
Phanerotrema grayvillense (Norwood and Pratten)
Worthenia tabulata (Conrad)
Orestes nodosus Girty
Trepospira depressa (Cox)
Bellerophon crassus var. *wewokanus* Girty
Pharkidonotus percarinatus (Conrad)
Patellostium montfortianum (Norwood and Pratten)
Euphemus carbonarius (Cox)
Schizostoma catilloides (Conrad)
Sphaerodoma primigenia (Conrad)

In spite of the striking similarity of the faunas of the Nellie Bly and the Wewoka, it is known that the two formations are not closely similar in age for a considerable thickness of sedimentary rocks intervenes between them. Furthermore, the ammonoids of the two are markedly different and this fact serves to emphasize the admitted superiority of ammonoids as indices for precise correlation of Late Paleozoic strata. Also, the ammonoids enable us to correlate the Nellie Bly with one of the upper members of the Gaptank formation of western Texas which yielded a fauna that has recently been described by A. K. Miller,[4] and we understand that Gayle Scott and F. B. Plummer[5] have found a closely similar and presumably synchronous ammonoid fauna in the Palo Pinto limestone (basal Canyon) of north-central Texas. The ammonoids alone, then, enable us to correlate the Nellie Bly with the Palo Pinto and with one of the upper members of the Gaptank, and to substantiate the generally accepted belief that there is no great difference in the age of the Canyon group of north-central Texas and the Kansas City group of the Mid-Continent region. Our correlation of the Nellie Bly with one of the members of the Gaptank is based on the fact that the ammonoid species *Prouddenites primus* and *Daraelites texanus* are common to the two, a representative of the genus *Marathonites* that is very closely related to *M. hargisi* Böse of the Gaptank occurs in the Nellie Bly, and, in addition, representatives of the ammonoid genera *Schistoceras* and *Gastrioceras* occur in both formations. Our correlation of these two horizons with the Palo Pinto limestone is based entirely on the as yet unpublished findings of Gayle Scott and F. B. Plummer mentioned above.

All of the fossils on which our study is based came from an outcrop of the Nellie Bly formation 6½ miles due

[4] Miller, A. K., A new ammonoid fauna of Late Paleozoic age from western Texas: *Jour. Paleontology*, vol. 4, pp. 383–412, 1930.
[5] Letter from F. B. Plummer to P. B. King, June, 1931.

west of Sand Springs, Oklahoma, on the Keystone road. Most of the specimens were collected by the junior author, but we are indebted to Miss Grace Ellen Shaw of San Antonio, Texas, Dr. Lowell R. Laudon of the University of Tulsa, and Mr. B. R. Mills of Tulsa, Oklahoma, who kindly furnished us with additional material.

SYSTEMATIC DESCRIPTIONS

Genus PSEUDORTHOCERAS Girty

PSEUDORTHOCERAS KNOXENSE (McChesney)
Plate 28, figure 30

Orthoceras knoxensis MCCHESNEY, *1860*, Descriptions of new species of fossils, p. 69, (1859). For a complete synonomy of this species see Miller, Dunbar, and Condra, *1933*, Nebraska Geol. Survey, 2d ser., Bull. 9, pp. 81–82.

This characteristic Pennsylvanian species is not rare in the Nellie Bly and it is represented in our collection from that formation by eleven fragmentary specimens, all of which are internal molds of part of the phragmacone; the largest attains a maximum diameter of about 10 mm. Recently, Miller, Dunbar, and Condra[6] have published an exhaustive description of this species, and since our specimens are typical both internally and externally a detailed description of them would add very little to the existing knowledge of the species and would, therefore, be superfluous.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma. This species is widely distributed in the Pennsylvanian of North America and it may occur in Europe also. In the Mid-Continent region it ranges from the Henrietta to the Wabaunsee; in north-central Texas it ranges from the Bend to the Cisco; and in western Texas it occurs in the Gaptank. Geographically it is known to range from Colorado on the west to Pennsylvania on the east, and from Texas on the south to Nebraska on the north. Recently Misch[7] and Heritsch[8] have referred to this species some specimens from the Upper Carboniferous near Nassfeld, in the Carnic Alps on the Austro-Italian border; in so far as we are able to tell from their descriptions and illustrations, these specimens do not differ essentially from the North American forms.

Figured specimen.—State University of Iowa, 627.

[6] Miller, A. K., Dunbar, C. O., and Condra, G. E., The Pennsylvanian nautiloids of the Mid-Continent region: *Nebraska Geol. Survey*, 2d. ser., Bull. 9, pp. 81–85, 1933.

Genus COLOCERAS Hyatt

COLOCERAS LIRATUM Girty?
Plate 28, figures 24–26

Coloceras liratum GIRTY, *1911*, New York Acad. Sci., Annals, vol. 21, p. 144; *1915*, U. S. Geol. Survey, Bull. 544, pp. 273–238, pl. 28, figs. 2–6*a*.—PLUMMER AND MOORE, *1922*, Texas Univ., Bull. 2132, p. 219 (1921).—MORGAN, *1924*, [Oklahoma] Bur. Geology, Bull. 2, p. 232, pl. 51, fig. 4.—MILLER, DUNBAR, AND CONDRA, *1933*, Nebraska Geol. Survey, 2d. ser., Bull. 9, pp. 132–134, pl. 6, figs. 1–8.

We have one small specimen which we are not able to differentiate from *Coloceras liratum* Girty. However, the internal sutures of the types of that species were not described by Girty and since those of our specimen are rather distinctive we hesitate to refer it unequivocally to Girty's species—until the internal sutures of the cotypes or topotypes of *C. liratum* are investigated the exact status of our specimen will remain uncertain.

Form subglobose as conch which is rapidly expanded orad is nautiliconic in its mode of growth and is strongly depressed dorso-ventrally. Whorls are sublunate in cross section as they are broad-

[7] Misch, Peter, *Pseudorthoceras knoxense* Girty im Karnischen Oberkarbon: *Mitt. Naturwissenschaftlichen Vereines f. Steiermark*, Bd. 67, pp. 121–122,1930.

[8] Heritsch, F., Versteinerungen aus dem Karbon der Karawanken und Karnischen Alpen: *Abh. geol. Bundesanst. Wien*, Bd. 23, Heft 3, pp. 42–43, text fig. 8, pl. 1, figs. 3–7, 1931.

ly rounded ventrally, very narrowly rounded laterally, and impressed dorsally. Our specimen is an internal mold of half of one volution of the phragmacone, and its maximum diameter, measured from the adoral part of the venter across the umbilicus to the opposite side of the specimen, is about 18 mm. Near the adoral end of the specimen the conch is about 15 mm. wide and 8 mm. high, and the impressed zone is about 5 mm. wide and 2 mm. deep; near the adapical end of the specimen these measurements are about 9 mm., 5 mm., 3 mm., and 1 mm. respectively. As is obvious from these figures, the conch is about half as high as wide and is impressed dorsally to about one-fourth its height. The umbilicus is moderately large and deep; its diameter is equal to about half that of the specimen. The umbilical shoulders are distinct and are very narrowly rounded, and the umbilical walls are somewhat convex and are very steep.

On the right side of the specimen a cast of a small portion of the test is retained

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EXPLANATION OF PLATE 28.

With the exception of the holotype of *Pericleites atticus* (figs. 37, 38), all of the specimens figured on this plate came from the Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma, on the Keystone road; the holotype of *P. atticus* came from the Upper Carboniferous of Attica, Greece.

FIGS. 1–3—*Prouddenites primus* Miller. Lateral and ventral views (×1) and diagrammatic representation of a suture (×4) of a mature specimen. (p .177)

4–6—*Wiedeyoceras pingue* Miller and Cline, n. sp. Lateral and ventral views (×4) and diagrammatic representation of a suture (×8) of the holotype. (p. 178)

7–9—*Gastrioceras millsi* Miller and Cline, n. sp. Ventral and lateral views (×4) and diagrammatic representation of a suture (×8) of the holotype. (p. 177)

10, 11—*Schistoceras* sp. Lateral view and diagrammatic representation of a suture of the only representative of this genus known from the Nellie Bly formation (×1). (p. 181)

12, 13—*Marathonites* sp. Lateral view (×2) and diagrammatic representation of a suture (×4) of the only representative of this genus known from the Nellie Bly formation. (p. 182)

14–18—*Goniolaboceras gracellenae* Miller and Cline, n. sp. Lateral and ventral views and diagrammatic representation of a suture of the holotype which represents the early mature portion of the phragmacone, and lateral view and diagrammatic representation of a suture of the largest paratype (×1). (p 175)

19–23—*Eupleuroceras bellulum* Miller and Cline, n. gen., n. sp. 19, Lateral view of a well-preserved cotype (×2); 20, 21, ventral and lateral views of another cotype showing subangular ventral keel (×2); 22, 23, lateral view (×2) and diagrammatic representation of a suture (×12) of a third cotype. Figures 19–22 are unretouched photographs. (p. 180)

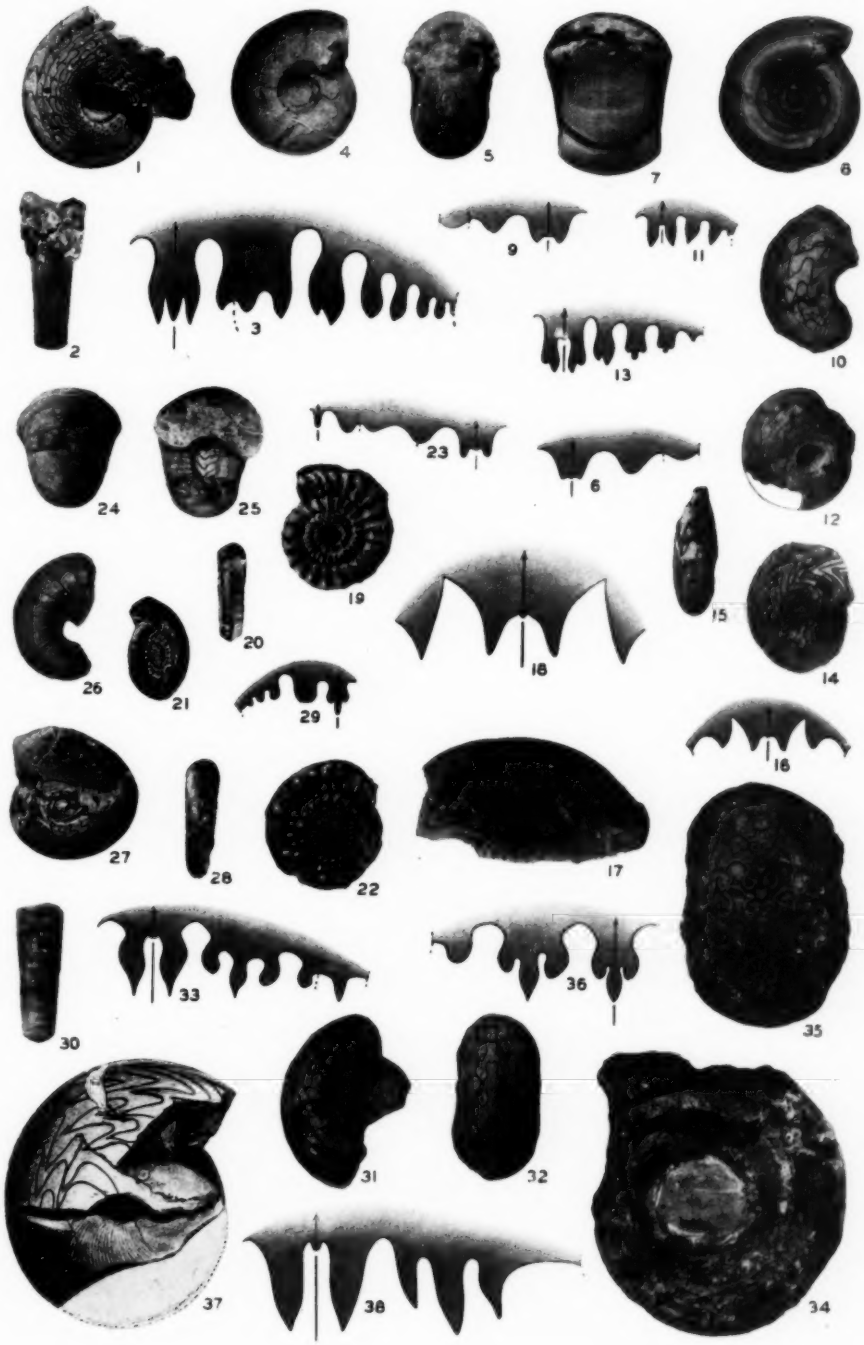
24–26—*Coloceras liratum* Girty? Ventral, dorsal, and lateral views (×1) of the only representative of *Coloceras* known from the Nellie Bly formation. The ventral view is in part restored. (p. 173)

27–29—*Daraelites texanus* Böse. Lateral and ventral views (×2) and diagrammatic representation of one of the adoral sutures (×4) of the only representative of *Daraelites* known from the Nellie Bly formation. (p. 176)

30—*Pseudorthoceras knoxense* (McChesney). A typical specimen representing only part of the phragmacone (×1). (p, 173)

31–36—*Shumardites senex* Miller and Cline, n. sp. Lateral and ventral views (×1) and diagrammatic representation of one of the external sutures (×2) of the smaller of the cotypes, and lateral and ventral views (×1) and diagrammatic representation of one of the internal sutures (×1½) of the larger of the cotypes; the suture lines visible on the ventral view of the latter specimen are not external sutures but they are traces of the internal sutures of the next whorl adorally. (p. 184)

37, 38—*Pericleites atticus* Renz, the genotype of *Pericleites*, from the Upper Carboniferous of Hagia Triada in Attica, Greece. Lateral view and diagrammatic representation of a suture of the holotype (×1). (Adapted from Renz.)



Miller and Cline, Pennsylvanian cephalopods

in the region of the umbilicus. This shows that on and near the umbilical shoulders the conch bore small rounded longitudinal lirae which were separated by relatively wide flat interspaces. Also, a trace of faint transverse lirae can be discerned on this portion of the specimen.

The sutures are directly transverse to the long axis of the conch and on the lateral sides of it they are essentially straight. On the broad ventral side, however, they form broad, very shallow lobes, and dorsad of the umbilical seam they curve gradually and then more rapidly apicad and form broad, moderately deep, narrowly rounded lobes as they cross the dorsum; on the adoral part of the specimen these lobes are relatively broader and less narrowly rounded than on the adapical.

A structure on the adapical end of the specimen that appears to represent the siphuncle is small, circular in cross section, and is located slightly dorsad of the center of the conch.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma. This species was described originally from the Wewoka formation of Oklahoma; it has since been identified from the Boggy shale (Cherokee), Copan shale (Kansas City), and the Wetumka formation (Henrietta) of Oklahoma, the Weston shale (Douglas) of Kansas, and the Graham shale (Cisco) and Jacksboro limestone (Cisco) of Texas.

Figured specimen.—State University of Iowa, 629.

Genus METACOCERAS Hyatt

METACOCERAS AFF. M. SINUOSUM Girty

Several fragmentary specimens in the collection we are studying are clearly referable to the genus *Metacoceras* but they do not appear to represent any described species. However, the general shape of their conchs, their broadly rounded umbilical shoulders, their prominent ventro-lateral nodes which are extended laterally as short ribs, and the course of the growth-lines across the flat ventral side of their conchs all indicate a relationship to *Metacoceras sinuosum* Girty [= *M. cornutum* var. *sinuosum* Girty] of the Wewoka formation of Oklahoma. None of them is complete enough or well enough preserved to merit figuring or describing in detail and we are mentioning them largely to record the occurrence of the genus *Metacoceras* in the Nellie Bly.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

Repository.—State University of Iowa, 630.

Genus GONIOLOBOCERAS Hyatt

GONIOLOBOCERAS GRACELLENAE
Miller and Cline, n. sp.
Plate 28, figures 14–18

Form subdiscoidal as conch is greatly flattened laterally and is ammoniticonic in its mode of growth and whorls are compressed laterally, rounded ventrally, and deeply impressed dorsally. Phragmacone attains a diameter, measured from adoral end of venter across umbilicus to opposite side of conch, of at least 40 mm. Maximum width of whorl is equal to about three-fifths maximum height, and whorls are impressed dorsally to about one-third their height. Umbilicus small but deep as umbilical walls are steep; the diameter of the umbilicus is only about one-tenth that of the specimen. Umbilical shoulders low, rounded, and inconspicuous. Nature of living chamber unknown.

Surface of internal mold, at least, smooth and marked by only the sutures. Unfortunately the internal sutures are not discernible on any of the types, but each external suture consists of a broad bifid ventral lobe and on either side of it two saddles and one lobe; there is a second lobe on the umbilical wall. The broad ventral lobe is divided by a prominent median saddle which is about half as deep as the lobe is high and becomes relatively deeper with age. This saddle is depressed-U-shaped but its sides are slightly sigmoidal and it is divided medi-

anly by a small, but very distinct, rounded tertiary lobe. The two prongs of the ventral lobe are slightly asymmetrical and are acute. The external saddle is broad but is much narrower than the ventral lobe and is asymmetrically V-shaped, but its ventral side is convex and its dorsal concave; on the early mature portion of the conch this saddle is very narrowly rounded but orad of there it becomes angular. The lateral lobe is similar in shape to the external saddle but it is more strongly asymmetrical and is shallower. The lateral saddle is relatively broad and is evenly rounded; it extends to the lobe on the umbilical wall which appears to be subacute.

Remarks.—The above description is based on six fragmentary internal molds which are only moderately well preserved. Most of these were collected by Miss Grace Ellen Shaw and the species is named in her honor.

The genotype of *Goniloboceras* is *G. goniolobum* (Meek), the only known representative of which came from some unrecorded locality and horizon in New Mexico. Recently Miller[9] removed from this genus all of the species that had been definitely referred to it except the genotype and placed them in *Milleroceras* and a then new genus *Gurleyoceras*. The species under consideration clearly represents *Goniloboceras* s. s. and not *Milleroceras* or *Gurleyoceras*, and it differs from *Goniloboceras goniolobum* in that the saddle in the ventral lobe of its sutures is more nearly U-shaped and less nearly V-shaped, and the prongs of the ventral lobe are less acuminate—*G. gracellenae* is distinctly more primitive than *G. goniolobum* and, therefore, the New Mexican species doubtlessly came from a higher horizon.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

[9] Miller, A. K., A Pennsylvanian cephalopod fauna from south-central New Mexico: *Jour. Paleontology*, vol. 6, pp. 69–77, 1932.

Types.—State University of Iowa, 631 (holotype) and 632 (paratypes).

Genus DARAELITES Gemmellaro

DARAELITES TEXANUS Böse

Plate 28, figures 27–29

Daraelites texanus BÖSE, *1919*, Texas Univ., Bull. 1762, pp. 52–54, pl. 1, figs. 1–8, (1917).—SMITH, J. P., *1929*, Am. Jour. Sci., 5th ser., vol. 17, pp. 66–68, fig. B, 17–26.—MILLER, A. K., *1930*, Jour. Paleontology, vol. 4, pp. 390–391, pl. 38, figs. 27–29.

This species was described in detail by Böse from specimens collected in western Texas in the upper part of the Pennsylvanian Gaptank formation [not the lower part of the Permian Wolfcamp formation as has heretofore been believed]. The original description has since been supplemented by J. P. Smith who studied the types and additional specimens from the same horizon, and by A. K. Miller who studied specimens from a slightly lower horizon in the same formation and the same general locality. Therefore, little remains to be added to the description of the species and it will suffice here to state that we have only one representative of this species and it appears to be typical in all respects. It is an internal mold of part of the phragmacone and it attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 10 mm. In the adoral sutures of this specimen the first lateral lobe and the lateral subdivisions of the trifid ventral lobe are serrate, but we have not been able to detect more than a trace of serrations on the second lateral lobe.

The genus *Daraelites* is widespread in the Permian and Upper Carboniferous and it occurs also in the Viséan of southern France. It is known from the Permian of Sicily, Timor, and the Ural and Pyrenees mountains, and from the Upper Carboniferous of Indo-China, Oklahoma (Wewoka formation), and Texas.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Okla-

homa. This species was originally described from the "Zone of *Uddenites*" in western Texas which was formerly believed to be lowermost Permian in age but is now regarded as part of the Pennsylvanian Gaptank formation, and it has since been recorded from a lower horizon ("Zone of *Prouddenites*") in the same formation in western Texas.

Figured specimen.—State University of Iowa, 633.

Genus PROUDDENITES Miller

PROUDDENITES PRIMUS Miller
Plate 28, figures 1–3

Prouddenites primus MILLER, *1930*, Jour. Paleontology, vol. 4, pp. 397–400, pl. 38, figs. 3–10.

This species is represented in our collection from the Nellie Bly by two internal molds. One of these represents a large portion of the phragmacone of a mature individual, but the other represents only the adolescent stage of the conch and it is so poorly preserved and incomplete that it can be disregarded. The general proportions of the conch and the shape of the sutures of the mature specimen coincide so closely with those of the types that there can be no question as to its identity—the fact that the central prong or subdivision of the sutures is slightly longer in this specimen than in the figured type of the species is of no significance as the relative length of this secondary lobe decreases adorally and our specimen is smaller than the figured type.

No morphological details are evidenced by this specimen that are not shown by the types and hence a detailed description of it would be superfluous. However, this specimen is exceedingly important because it indicates that the Nellie Bly is the correlative of the portion of the Gaptank formation of western Texas which yielded the types of *Prouddenites*, and that the "Zone of *Prouddenites*" is not uppermost Pennsylvanian as was originally believed but rather that it lies near the middle of the Pennsylvanian system. Furthermore, we understand that F. B. Plummer and Gayle Scott have found in the Palo Pinto limestone (basal Canyon) of north-central Texas an ammonoid fauna that is closely similar to the fauna of the "Zone of *Prouddenites*" in western Texas, and for some time it has been believed that the lower portion of the Canyon is the approximate time equivalent of the Kansas City group of which the Nellie Bly is a member.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma. This species occurs also in one of the upper members of the Gaptank formation near Lenox, western Texas.

Repository.—State University of Iowa, 634.

Genus GASTRIOCERAS Hyatt

GASTRIOCERAS MILLSI Miller and Cline, n. sp.
Plate 28, figures 7–9

This species is being established for a single small well-preserved specimen which was sent to us by Mr. B. R. Mills of Tulsa, Oklahoma, who also sent us the holotype of *Wiedeyoceras pingue*. The specific name is, of course, given in honor of Mr. Mills.

Form subglobose as conch is ammoniticonic in its mode of growth and whorls are strongly depressed dorso-ventrally, broadly rounded ventrally and ventrolaterally, subangular laterally, and slightly impressed dorsally. The umbilicus is very large and deep and the umbilical walls are fairly steep; the lateral zones of all of the inner whorls are exposed in the umbilicus and it can be seen that the holotype consists of about five and one-half volutions. The umbilical walls are very slightly convex and the whorls are subtrapezoidal in cross section. The holotype attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 5.5 mm. and a maximum width of about 4.5 mm. The conch is about one-third as high as wide and it is impressed dorsally to about one-third its height. The di-

ameter of the umbilicus is equal to about three-fifths that of the specimen.

Although the holotype is an internal mold, it retains traces of relatively coarse growth-lines. These are essentially straight on the umbilical walls but they swing somewhat orad as they cross the broad ventral side of the conch; however they appear to curve slightly apicad as they cross the venter and this may indicate the presence of a very shallow hyponomic sinus.

The outer volution of the holotype is marked also by three deep rounded constrictions. On both sides of the umbilical shoulders these constrictions slope orad and they form moderately deep "saddles" as they cross the nearly flat ventral side of the conch; these "saddles" however are somewhat flattened medianly.

The holotype appears to be septate throughout but in all but the extreme adapical part of the outer volution the sutures are very faint. Each external suture consists of a short broad ventral lobe and on either side of it two saddles and one lobe; there is an additional lobe on the umbilical wall. The ventral lobe is divided by a broad shallow secondary saddle which, in turn, is divided by a very short, broad, broadly rounded ventral lobe. The two major subdivisions of the ventral lobe are bluntly pointed. The external saddle is asymmetrical and it is broad, broadly rounded, and undivided. The first lateral lobe is considerably smaller than the ventral lobe and it is bluntly pointed. The first lateral saddle is located on the umbilical shoulder; it is broad, shallow, and rounded, and it is slightly asymmetrical. The lobe on the umbilical wall is short, broad, and broadly rounded.

Remarks.—This species is quite distinct from all previously described forms but it is somewhat similar to *Gastrioceras angulatum* Girty of the Wewoka formation of Oklahoma, *G. subtilicostatum* Böse of the Upper Pennsylvanian (Abo?) of New Mexico, *G. welleri* Smith of the Lower Pennsylvanian of Missouri, and *G. subcavum* Miller and Gurley of the Upper Pennsylvanian of Illinois and possibly the Cisco of Texas; all of these species are characterized by the possession of low flat whorls, wide deep funnel-shaped umbilici, and angular umbilical shoulders. *G. angulatum*, however, is wider and more nearly globose than *G. millsi* and the details of its sutures are markedly different. *G. subtilicostatum* Böse is characterized by the possession of small elongate nodes or short ribs on the umbilical shoulders, whereas the umbilical shoulders of our species are smooth; also the sutures of the two species are not precisely similar. *G. welleri* has a narrower umbilicus than has *G. millsi*, its umbilical shoulders are sharper, and its sutures present certain significant differences particularly in the nature of the ventral lobe. *G. subcavum* is wider and more nearly globose than *G. millsi* and its umbilicus is narrow, its umbilical shoulders are sharper, and its sutures are markedly different.

Our collection from the Nellie Bly contains in addition to the above-described specimen numerous larger fragmentary representatives of the genus *Gastrioceras*, some of which attain a diameter of more than 20 mm. These specimens appear to represent several species but all of them are too poorly preserved or incomplete to merit detailed description and satisfactory comparisons with *G. millsi* can not be made.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

Holotype.—State University of Iowa, 635.

Genus WIEDEYOCERAS Miller

WIEDYOCERAS PINGUE
Miller and Cline, n. sp.
Plate 28, figures 4–6

Shell small. Form subglobose as conch is moderately rapidly expanded orad, ammoniticonic in its mode of growth, and somewhat depressed dorso-ventrally. Whorls are helmet-shaped in cross-sec-

tion as they are rounded ventrally and ventro-laterally, almost flat laterally, very narrow dorso-laterally, and somewhat impressed dorsally. Holotype, a well-preserved internal mold representing all of the phragmacone and much of the living chamber, attains a maximum diameter, measured from adoral end of venter across umbilicus to opposite side of specimen, of about 5 mm. and a maximum width of about 3.4 mm. The conch is about two-thirds as high as wide and it is impressed dorsally to about one-sixth its height. The living chamber is probably at least one volution in extent.

The umbilicus is deep and its diameter is equal to about one-third that of the specimen. The umbilical walls, though slightly convex, are very steep. The umbilical shoulders are very narrowly rounded. On the outer volution of the holotype there are twelve small, low, rounded nodes on each umbilical shoulder—these nodes seem to be somewhat extended laterally to form short indistinct lateral ribs. The outer volution of the holotype is marked also by four very distinct rounded constrictions. These curve distinctly orad on the lateral zones of the conch but on the ventro-lateral zones this curvature is reversed and the constrictions form shallow "lobes" as they cross the venter.

The internal sutures of this species are not known, but each external suture consists of a ventral lobe and on either side of it two saddles and one lobe; there is a second lobe on the umbilical wall. The ventral lobe is short and broad and it is divided by a very shallow median saddle which, in turn, is subdivided by a tertiary lobe that is nearly as large as the two prongs or major subdivisions of the ventral lobe. All three of these secondary and tertiary lobes are pointed-V-shaped and they are separated by similar tertiary saddles which, however, are less sharply pointed. The external saddle is almost as large as the ventral lobe, but it is depressed-U-shaped as it is broadly rounded adorally and its sides are almost straight. The first lateral lobe is similar in shape to the external saddle but it is somewhat smaller and is more narrowly rounded. The first lateral saddle is located on the umbilical shoulder; it is broad, shallow, broadly rounded, and slightly asymmetrical. The lobe on the umbilical wall also is broad, shallow, and broadly rounded.

Remarks.—This small form is the most abundant cephalopod species in the Nellie Bly formation, and although the above description is based largely on the holotype, ten paratypes are available for comparisons. Only three other species of the genus *Wiedeyoceras* are known. The genotype, *W. sanctijohanis* (Wiedey) of the Lower Pennsylvanian of Iowa, is a narrower form and its sutures are markedly different in that the secondary saddle in the ventral lobe is deeper, the external saddle and lateral lobe are relatively narrower, and the first lateral saddle is relatively wider. *W. lineolatum* Miller of the Upper Pennsylvanian (Abo?) of New Mexico likewise is narrower and is more nearly discoidal than globose; also the components of its external sutures are relatively narrower. *W. nodomarginatum* Miller of the Upper Pennsylvanian (Abo?) of New Mexico is perhaps more closely related to our form than is any other described species but its conch is narrower, the nodes on its umbilical shoulders are much more prominent, and the first lateral lobes of its sutures are much smaller.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

Types.—State University of Iowa, 636 (holotype) and 637 (paratypes).

Genus EUPLEUROCERAS Miller and Cline, n. gen.

We propose the generic name *Eupleuroceras* for four specimens from the Nellie Bly which are clearly conspecific but are not referable to any previously described genus or species. The sutures of these forms are gastrioceran-like in that each

complete suture consists of a total of eight primary lobes and eight primary saddles, but as is shown below they present certain significant differences from those of *Gastrioceras* s. s. and in addition the conch is almost subcircular in cross section, is only very slightly impressed dorsally, and is marked laterally by very prominent transverse ribs and ventrally by a small sharp median keel—the surface ornamentation is one of the most significant of the generic characters and calls to mind such Cretaceous genera as *Pervinquieria* and *Oxtropidoceras*. It is not intended by the generic name to indicate a relationship to *Pleuroceras* Hyatt not Rafinesque [= *Paltopleuroceras* Buckman] of the Jurassic.

No other species are known to us that are congeneric with the genotype, *Eupleuroceras bellulum*, described below, and the genus can be briefly diagnosed as follows: Form subdiscoidal as conch is ammoniticonic in its mode of growth but is only slightly impressed dorsally, is unequally pentagonal in cross section, and is very gradually expanded orad. Whorls are marked laterally by prominent transverse ribs which end abruptly on the ventro-lateral zones in small nodes. Also there is a small but very distinct subangular ventral keel. Each complete suture consists of a total of eight primary lobes and eight primary saddles. The ventral lobe is divided by a rather prominent median saddle but all of the other lobes and all of the primary saddles are undivided. The dorsal lobe is very narrow and it is widely separated from the lateral lobes of the internal sutures.

The form of the conch and the surface ornamentation in this genus as well as the peculiar shape of the internal sutures serve to distinguish it from such genera as *Gastrioceras*, *Nomismoceras*, etc., with which it might be confused.

EUPLEUROCERAS BELLULUM
Miller and Cline, n. sp.
Plate 28, figures 19–23

Shell small and subdiscoidal. Conch is ammoniticonic in its mode of growth but is not tightly coiled and is not deeply involute. Whorls are unequally pentagonal in cross section and conch is expanded orad very slowly. The largest of the cotypes consists of about six volutions and it attains a maximum diameter measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 11 mm., and a maximum width of about 2 mm. Whorls are depressed dorso-ventrally and are unequally pentagonal in cross section; their dorsal side is concave, their lateral sides are slightly convex, and their ventral or ventro-lateral sides, which are inclined to each other at an angle of about 130 degrees, are nearly flat. The junctions of the five sides are all very narrowly rounded or angular. The umbilicus is very large and all of the lateral sides of all of the volutions are exposed.

The lateral sides of the conch bear prominent subangular transverse ribs or costae which are separated by relatively wide smooth concave interspaces; there are about twenty-four of these ribs or costae to the volution. They extend from the umbilical seam ventrad to the very narrowly rounded or subangular ventro-lateral zone of the conch where they end abruptly by expanding into short rounded nodes. The ventral portion of the conch is essentially smooth but it is marked medianly by a sharp angular longitudinal keel. On well-preserved specimens the sutures can be seen cutting directly across this keel.

Each complete suture consists of a total of eight primary lobes and eight primary saddles. The ventral lobe is short and broad and it is divided by a broad shallow secondary saddle which in turn is divided medianly by a short broad rounded tertiary lobe; the secondary saddle is about one-fourth as deep as the ventral lobe is long, and the major prongs or subdivisions of the ventral lobe as subangular. The first lateral saddle is somewhat smaller than the ventral lobe and it is asymmetrically depressed-U-shaped. The first lateral lobe is similar

in shape to the external saddle but it is smaller and is essentially symmetrical; it is located on the very narrowly rounded or subangular ventro-lateral zone of the conch. The first lateral saddle is very broad and shallow and is broadly rounded. The second lateral lobe is broad, shallow, asymmetrical, and subacute. It is followed by a small, shallow, relatively narrow, rounded saddle that is located on the umbilical seam. Dorsad of this saddle there is a very asymmetrical, very narrowly rounded lobe and a fairly deep, asymmetrically U-shaped saddle which is followed by a moderately long, narrow, linear, narrowly rounded lobe, the dorsal lobe. The saddles which separate the dorsal lobe from the rest of the suture are relatively large and very asymmetrical and the dorsal lobe therefore appears to be more or less isolated.

Remarks.—This species is so distinct from all other described forms that specific comparisons are unnecessary. *Gastrioceras branneri* Smith of the Morrow group of Arkansas superficially appears to be somewhat similar but its lateral costae or ribs are much less prominent, its venter is not keeled, and its sutures are markedly different, so that we do not regard the two species as being even congeneric.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

Cotypes.—State University of Iowa, 638.

Genus SCHISTOCERAS Hyatt

SCHISTOCERAS sp.
Plate 28, figures 10, 11

The genus *Schistoceras* is represented in our collection from the Nellie Bly by a single incomplete internal mold which represents the left side of about half of one of the volutions of the phragmacone. This specimen is somewhat crushed and is only moderately well preserved, but it retains its sutures and surface ornamentation and many of its specific characters can be discerned. The preserved part of the conch attained a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 21 mm. (estimated), and a maximum height of about 10 mm.; due to the crushed nature of the specimen the width of the conch can not be determined. The diameter of the umbilicus appears to be equal to about one-third of the diameter of the specimen.

The adapical third of this specimen is marked by small but very distinct, rounded, transverse ribs, which appear to extend from the umbilical shoulder to the ventro-lateral zones of the conch. These ribs serve to distinguish this form from all other described representatives of *Schistoceras* except *S. hildrethi* (Morton) of the Conemaugh of Ohio and possibly the Cisco of Texas. Similar ribs are present in the adolescent stage of the conchs of other species belonging in the genus *Schistoceras* and this fact, together with the shape of the sutures of our specimen, indicates that our form is a relatively primitive member of the genus.

The nature of the sutures is shown more clearly by our diagrammatic illustration than it can be depicted in words, but we want to call attention to the fact that the ventral saddle is rather shallow for this genus, and the third lateral lobe is very small and is located close to the umbilical shoulder. The ventral portion of the specimen is crushed and somewhat distorted and therefore our representation of the ventral lobe is somewhat restored. There appears to be a small lobe, comparable in size to the third lateral lobe, on the umbilical wall just inside the umbilical shoulder, but that part of the specimen is not well preserved.

This specimen appears to be specifically distinct from all previously described forms, but we are refraining from coining a specific name for it because of its incompleteness. Its sutures and surface ornamentation clearly indicate that it is distinctly more primitive than any representative of the genus *Schistoceras* that has been described previously. It is more closely related to *S. hildrethi* (Mor-

ton) than to any other described form, but it differs from that species in that transverse ribs are developed on not only the adolescent but also on the early mature portion of its conch. Also, the sutures of the two forms are not precisely similar; this is particularly noticeable in the case of the third lateral lobe which in our form is smaller and is located closer to the umbilical shoulder than in *S. hildrethi*. Also the umbilical shoulders of the Nellie Bly species appear to be much more abrupt than those of *S. hildrethi*.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

Figured specimen.—State University of Iowa, 639.

Genus MARATHONITES Böse

MARATHONITES sp.

Plate 28, figures 12, 13

The collection we are studying contains a specimen that clearly represents the genus *Marathonites* but it not referable to any described species; however, it is so poorly preserved that we are refraining from assigning it a name and thereby making it the type of a species. This specimen is an internal mold of the left half of part of the phragmacone. Although none of its sutures is preserved in its entirety, portions of several of them can be discerned and the diagrammatic representation of a suture that we are including is composite. The ventral portion of the specimen appears to have been compressed laterally during preservation and therefore that part of the sutures is probably not accurately represented by our diagram.

The conch of this specimen was subglobose and the umbilicus rather small. The maximum diameter of the specimen, measured from the adoral end of the preserved part of the venter across the umbilicus to the opposite side of the specimen, is about 14 mm.; since the specimen is septate throughout, this of course does not represent the maximum size attained by the conch. Due to imperfections of the specimen, the width of the conch can not be determined. The diameter of the umbilicus is equal to about one-fifth that of the specimen. No trace of constrictions or markings other than sutures is discernible on the specimen.

Each external suture consists of a divided ventral lobe and on either side of it four lateral lobes—the nature of the internal sutures is not known. The ventral lobe is symmetrical and it is divided by a secondary saddle which is about half as deep as the lobe is long; the prongs of the ventral lobe are unequally bifid as their ventral subdivisions are considerably longer than their dorsal. The first lateral lobe, which is club-shaped, is unequally bifid and its dorsal subdivision is longer than its ventral. The second lateral lobe is trifid and its median subdivision is considerably longer than its lateral ones which are subequal. The third lateral lobe is similar in shape to the second but it is shorter and relatively broader and its subdivisions are less distinct. The fourth lateral lobe, i.e., the first auxiliary lobe, is asymmetrically depressed-V-shaped. All of the saddles are rounded, undivided, and more or less tongue-shaped. The fourth lateral saddle is located on the umbilical shoulder.

Remarks.—This species is closely related to *Marathonites hargisi* Böse of the Gaptank formation of western Texas, which may be a synonym of "*Ammonites*" *parkeri* Heilprin of north-central Texas, but it differs from that species in that its third lateral lobe is trifid and not bifid and its conch appears to be narrower and therefore less nearly globose. Karpinsky[10] has described as "*Popanoceras* sp. indeterm. (aff. *Parkeri* Heilprin)" a small fargmentary specimen from the Artinsk beds of the southern Urals in which the first lateral lobe is bifid, the second trifid, and the third

[10] Karpinsky, A., Über die Ammoneen der Artinsk-Stufe und einige mit denselben verwandte carbonische Formen: *Mém. de l'Acad. Imp. des Sci. de St.-Pétersbourg*, VIIe sér, t. 37, no. 2, pp. 75–76, pl. 5, figs. 5*a–c*, 1889.

probably trifid. However, the rest of the suture of this form is not known, and also the dorsal subdivisions of the branches of the ventral lobe are longer than the ventral whereas in our form the reverse is the case.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

Figured specimen.—State University of Iowa, 640.

Genus SHUMARDITES Smith

This genus was established in 1903 by J. P. Smith,[11] who based it on four conspecific specimens from the Wayland shale member of the Graham formation (basal Cisco) of north-central Texas—the specific name *Shumardites simondsi* was proposed at the same time for these specimens. Since then Miller[12] has mentioned the occurrence of this genus in the Upper Pennsylvanian (Abo? sandstone) of south-central New Mexico, and Leuchs[13] has referred to it some specimens from the Upper Carboniferous of the central Tien Shan, near the eastern border of Russian Turkestan.

Leuchs' specimens are crushed and rather poorly preserved, but as has been noted by Schmidt[14] they probably are more closely related to *Pericleites atticus* Renz, the genotype of *Pericleites*,[15] than to the genotype of *Shumardites*. *Pericleites* is undoubtedly closely related to *Shumardites* but it differs particularly in that its external sutures possess one less lateral lobe, and it is therefore nearer to their common ancestor. We are including reproductions of the original illustrations of the genotype of *Pericleites* for they are not readily available to most American paleontologists and the genus is almost certainly represented on this continent (Finis shale of Texas).

Relatively recently Rauser-Tschernooussova[16] has proposed the generic name *Proshumardites* for a species, *P. karpinskii*, from the Carboniferous of Fergana in the southeastern part of Russian Turkestan. As has been noted by Schindewolf,[17] *Proshumardites karpinskii* is apparently congeneric with *Pericleites atticus*, and the generic name *Proshumardites* is therefore to be suppressed as a synonym of *Pericleites*.

J. P. Smith,[18] calling attention to the apparent similarity of the mature sutures of *Shumardites* to those of *Hyattoceras*, postulated that *Shumardites* was the ancestral radical of the Cyclolobidae of the Permian, of which *Hyattoceras* is a typical representative. This relationship can not be considered established until the ontogeny of *Hyattoceras* has been investigated, and unfortunately all of the representatives of *Hyattoceras* that we have had an opportunity to study came from the Sosio beds of Sicily and their preservation is such that their ontogenetic development can not be investigated satisfactorily. J. P. Smith also stated that *Shumardites* in its ontogenetic development went through stages that correspond to the genera *Gastrioceras*, *Paralegoceras*, and *Schistoceras*. However, Mil-

[11] Smith, J. P., The Carboniferous ammonoids of America: *U. S. Geol. Survey, Mon.* 42, pp. 134–135, 1903.

[12] Miller, A. K., A Pennsylvanian cephalopod fauna from south-central New Mexico: *Jour. Paleontology*, vol. 6, p. 93, footnote, 1932.

[13] Leuchs, Kurt, Marines Oberkarbon im zentralen Tianschan: *Sitzungsberichte Bayerischen Akad. Wiss., Math.-physik. Klasse*, pp. 222–223, pl. 1, figs. 2–7, Jahrg. 1919.

[14] Schmidt, Hermann, Die carbonischen Goniatiten Deutschlands: *Jahrb. Preuss. Geol. Landesanstalt*, Bd. 45, p. 599, 1925.

[15] The genus *Pericleites* was based on a specimen from the Upper Carboniferous of Attica, in Greece, and it was established by Renz (*Jahrb. K.-K. geol. Reichsanstalt*, Bd. 60, pp. 464–467, text fig. 4, pl. 18, fig. 5, 1910) who regarded it as a subgenus of *Paralegoceras*. In our opinion it belongs in the same family as *Paralegoceras*, but it is not particularly closely related to it.

[16] Rauser-Tschernooussova, D. M., Ueber die Carbonammonitenfauna von Fergana: *Bull. de l'Assoc. de Recherches scientifiques à la Faculté des sciences de la Ire Université de Moscou*, Tom 1, pp. 165–167, 177, 1928.

[17] Schindewolf, O. H., *Neues Jahrb. f. Min., Geol. u. Pal.*, Referate 3, p. 107, Jahrgang 1930.

[18] *Op. cit.*, p. 135.

ler[19] has shown that *Paralegoceras* developed from *Gastrioceras* by the formation of an additional lobe in the suture in the region of the umbilicus, and *Schistoceras* arose directly from *Paralegoceras* by the third lateral lobe becoming tripartite; in *Metalegoceras* the second lateral lobe of a *Gastrioceras*-like form became tripartite, and in *Shumardites* the first lateral lobe of a similar form became tripartite. It therefore seems to us that *Shumardites* should be removed from the Cyclolobidae and grouped with *Gastrioceras*, *Paralegoceras*, *Schistoceras*, and *Metalegoceras* in the Goniatitidae.

SHUMARDITES SENEX Miller and Cline, n. sp.
Plate 28, figures 31–36

Two moderately well preserved but incomplete internal molds in our collection represent an undescribed species of the genus *Shumardites* for which we propose the name *Shumardites senex*. Both of these specimens are septate throughout and, therefore, represent only part of the phragmacone; furthermore, on even the adoral end of the larger specimen there are traces of the internal sutures of an additional volution, proving that the phragmacone of this specimen, when complete, was at least one more volution in extent.

Form subglobose as conch is rapidly expanded orad and is ammoniticonic in its mode of growth and whorls are rather strongly depressed dorso-ventrally. The preserved part of the larger of the cotypes attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of about 48 mm.; the diameter at right angles to this measures about 41 mm. At the adoral end of this specimen the conch is about 28 mm. wide and about 13 mm. high. At the adoral end of the penultimate volution the conch is about 22 mm. wide and 10 mm. high. The whorls are helmet-shaped in cross section as they are broadly rounded ventrally and laterally, subacute dorsal-laterally, and impressed dorsally; the depth of the impressed zone is equal to almost one-half the height of the whorl.

The umbilicus is large but deep, and its sides are stepped. The umbilical shoulders are subangular, and the umbilical walls are very steep. The diameter of the umbilicus is equal to almost one-half that of the specimen; the preserved part of the umbilicus of the larger of the cotypes attains a maximum diameter of about 21 mm.

The internal mold is smooth and apparently is devoid of markings other than the sutures. Each complete suture consists of a total of twelve primary lobes and twelve primary saddles; five of the primary lobes are located on the external part of the conch, five on the internal, and two on the intermediate zones, i.e., on the umbilical walls; the primary saddles are equally distributed between the internal and external portions of the conch. The ventral lobe is large and broad and it is divided medianly by a very deep, bottle-shaped, secondary saddle, which in turn is divided medianly by a small, rounded, tertiary lobe. Each of the major prongs of the ventral lobe is asymmetrical, acuminate, and more or less sigmoidal. The external saddle is relatively small and is tongue-shaped—it, like all of the other primary saddles, is undivided. The first lateral lobe is exceedingly broad but relatively short and it is unequally tripartite; its two outer subdivisions are not sharply pointed and are not straight but its median subdivision, though not symmetrical, is essentially straight and is very acuminate—the median subdivision is somewhat longer than the two outer ones which are subequal in size. The first lateral saddle is somewhat similar in shape to the external saddle, but it is shorter, broader, and less strongly tongue-shaped. The second lateral lobe is located just ventrad

[19] Miller, A. K., *Metalegoceras jacksoni* of the Irwin River coalfield, Western Australia: *Am. Jour. Sci.*, 5th ser., vol. 24, pp. 433–441, 1932.

of the umbilical shoulder; it is not sharply pointed, and it is asymmetrical and is curved slightly dorsad. There is a short, broad, depressed-U-shaped, asymmetrical saddle located on the umbilical shoulder and a similar one on the umbilical seam; these are separated by a pointed, V-shaped, symmetrical lobe located on the umbilical wall. The dorsal lobe is trifid; its two outer subdivisions, which are equal in size, are short and rounded, but its central subdivision is relatively long and is sublanceolate. On either side of the dorsal lobe there is a moderately short, broad, tongue-shaped saddle, a short, very broad, trifid lobe, a short, broad, rounded, U-shaped saddle, and a smaller, shorter, rather broad, rounded, U-shaped lobe which is followed by the saddle on the umbilical seam mentioned above. The trifid lateral lobe of the internal sutures is not symmetrical; its outer subdivisions are narrowly rounded to subangular and are distinctly curved and the dorsal one is considerably larger than the ventral; its central subdivision is straight, acuminate, and sublanceolate.

Remarks.—Only two other representatives of this genus are known. *S. simondsi* Smith of the Wayland shale (Cisco) of Texas is a much more advanced form than our species as the secondary lobes of its external sutures are all digitate at maturity. The form from the Upper Pennsylvanian (Abo? sandstone) of south-central New Mexico that Miller[20] mentioned but did not illustrate, describe in detail, or name, is marked by very distinct transverse lirae whereas in our species the internal mold, at least, is smooth.

Occurrence.—Nellie Bly formation, 6½ miles due west of Sand Springs, Oklahoma.

Cotypes.—State University of Iowa, 641.

[20] Miller, A. K., A Pennsylvanian cephalopod fauna from south-central New Mexico: *Jour. Paleontology*, vol. 6, p. 93, footnote, 1932.

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FORAMINIFERA AND OSTRACODA FROM THE UPPER CRETACEOUS OF KANSAS[1]

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ABSTRACT

Samples collected from the formations of the Colorado group have yielded 37 species of foraminifera and seven species of Ostracoda. Of the 23 genera represented, 20 are foraminifera. Most of the species appear to be restricted to two horizons, middle Greenhorn and basal Niobrara. Twenty-eight species are believed to be new.

This paper has resulted from a study of many samples collected from the various formations and members of the Colorado group in Kansas while the author was engaged in field work during the past four summers. Most of these samples yielded only the very common species of *Gümbelina* and *Globigerina*. This fact has undoubtedly tended to discourage microscopic study in this region even though there was apparently no good explanation of this paucity of species. Fortunately a few samples proved to be quite rich in their foraminiferal content, indicating that these formations, if carefully studied, may be found to contain a microscopic fauna comparable in number of species to the Texas and Gulf Coast Cretaceous. Not the least interesting is the discovery of ostracodes in the Greenhorn and Niobrara formations.

In view of the scores of publications treating of the Cretaceous faunas, the large proportion of new species in this fauna may at first seem surprising. However, when we consider that a large part of the studies on American Upper Cretaceous foraminifera have dealt with faunas from beds considerably younger than those of the Colorado group, this condition seems rather to be expected.

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[1] Presented as part of the dissertation requirement for the degree of Doctor of Philosophy in the Department of Geology at Yale University.

RÉSUMÉ OF LITERATURE

The following brief résumé of the literature may be helpful to those interested in the microfauna of the Interior Province. The ostracode references include papers on the Cretaceous of North America, whereas the references to foraminifera deal with Mid-Continent Upper Cretaceous.

1841—J. W. Bailey (**5,** pp. 400–401) describes a sample of "prairie chalk" which was sent to him from the Niobrara of the northwest, and gives four figures of "*Polythalamia*" which according to Calvin (**14,** p. 149) are common species in the Cretaceous chalk of England and America.

1843—Ehrenberg (**6**) devotes a few pages of this work to a discussion of the foraminifera, including forms from along Missouri river.

1854—Ehrenberg (**7,** p. 132). This work contains illustrations of forms referred to in Ehrenberg's previous work. The plates have been reprinted by Cushman (**25,** pp. 113–115, pls. 34–36). Plate 34 illustrates forms from the Cretaceous chalk of the upper Missouri region. Twenty species are shown.

1890—S. W. Williston (**11**) recognized the presence of foraminifera in the Cretaceous rocks of Kansas for the first time. Though no specific assignments were made he noted several different forms, the most abundant being ascribed to the genus *Textularia* [evidently *Gümbelina*].

1893—Woodward and Thomas (**12**). This comprehensive paper describes and figures the largest variety ever reported in the Interior Cretaceous area north of Texas. Eighteen genera and thirty species are treated.

1893—S. Calvin (**13,** pp. 213–236). This report on the Iowa chalk lists and figures eight species with three specific assignments, *Globigerina cretacea*, *G.* aff. *digitata*, and *Textularia globulosa*.

1898—C. E. McClung (**16,** pp. 415–427). This brief paper includes all that was then known of the Upper Cretaceous foraminifera in Kansas. The following species are figured and described: *Orbulina universa* d'Orbigny, *Textularia globulosa* Ehrenberg, *Globigerina bulloides* d'Orbigny, *Globigerina spinosa* McClung.

1925—Willard Berry (**18,** pp. 481–487, figs. 1–15) describes and illustrates thirteen new species from the Upper Cretaceous of Maryland. Alexander reports several of these species in the Navarro of Texas.

1927—W. L. Moreman (**23,** pp. 89–101, pls. 13–16) figures and describes two species, *Bairdia subdeltoidea* (Münster) and *Cytherella muensteri* (Roemer) from the Eagle Ford of Texas.

1927—C. I. Alexander (**24,** pp. 29–33, pl. 6) in a paper on *Bairdia subdeltoidea* divides this species into two additional new species and one variety and demonstrates the stratigraphic value of these new forms.

1928—H. C. Vanderpool (**26,** pp. 98–107, pls. 13, 14) figures and describes eight new species and two new varieties from the Trinity of Arkansas and Texas.

1929—Katherine Carman (**28,** pp. 309–315) describes and figures eight species from the Benton and Niobrara of Wyoming.

1929—M. C. Israelsky (**31**) in a study of the Upper Cretaceous ostracodes of Arkansas reports 26 species, of which 24 are described as new.

1929—C. I. Alexander (**30**). This is to date the most comprehensive work on Cretaceous Ostracoda in this country. Ninety-three species are treated, fifty-seven being new. Eighteen species occur in the Eagle Ford and Austin, but unfortunately none of these could be recognized in the small ostracode fauna of the present paper.

1933—H. C. Vanderpool (**38,** pp. 406–411, pl. 49) describes four new species of ostracodes and reports the occurrence of nine additional species in the upper Trinity of southern Oklahoma.

STRATIGRAPHIC DISTRIBUTION

The following table shows the relative abundance and known vertical range of

TABLE SHOWING STRATIGRAPHIC DISTRIBUTION OF MICROFOSSILS FROM ROCKS OF THE COLORADO GROUP IN KANSAS[2]

	Graneros	Greenhorn				Carlile		Niobrara	
		Lincoln	Hartland	Jetmore	Pfeifer	Fairport	Blue Hill	Fort Hays	Smoky Hill
FORAMINIFERA									
Lenticulina sublaevis Morrow, n. sp.	—	—	—	—	—	—	—	C	—
Lenticulina kansasensis Morrow, n. sp.	—	—	—	—	—	—	—	C	—
Dentalina reflexa Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Dentalina sp.	—	—	—	—	—	—	—	P	—
Nodosaria alternistriata Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Vaginulina niobrarensis Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Vaginulina knighti Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Vaginulina rectilateralis Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Vaginulina subcomarginata Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Vaginulina cf. *texana* Cushman	—	—	—	—	—	—	—	P	—
Frondicularia dunbari Morrow, n. sp.	—	—	—	—	—	—	—	C	—
Frondicularia extensa Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Frondicularia aclis Morrow, n. sp.	—	—	—	—	—	—	—	R	—
Frondicularia sp.	—	—	—	—	—	—	—	P	—
Frondicularia sp.	—	—	—	—	—	—	—	R	—
Flabellina cushmani Morrow, n. sp.	—	—	—	—	—	—	—	R	—
Gümbelina globulosa (Ehrenberg)	—	C	C	C	C	C	—	C	C
Gümbelina globifera (Reuss)	—	C	C	C	C	C	—	C	C
Eouvigerina geneae Morrow, n. sp.	—	—	—	—	—	—	—	C	—
Hantkenina trituberculata Morrow, n. sp.	—	—	C	—	—	—	—	—	C
Bulimina reussi n. n.	—	—	—	—	—	—	—	C	—
Bulimina sp.	—	—	—	—	—	—	—	C	—
Bolivina tegulata (Reuss)	—	—	—	—	—	—	—	R	—
Pleurostomella nitida Morrow, n. sp.	—	—	R	—	—	—	—	P	—
Nodosarella n. sp.	—	—	—	—	—	—	—	R	—
Valvulineria infrequens Morrow, n. sp.	—	—	—	—	—	—	—	R	—
Gyroidina nitida (Reuss)	—	—	—	—	—	—	—	C	—
Gyroidina lenticula (Reuss)	—	—	—	—	—	—	—	C	—
Globigerina cretacea d'Orbigny	R	C	C	C	C	C		R	C
Hastigerinella simplex Morrow, n. sp.	—	—	C	—	—	—	—	—	—
Globorotalia cushmani Morrow, n. sp.	—	—	C	—	—	—	—	—	—
Globorotalia multiloculata Morrow, n. sp.	—	—	C	—	—	—	—	—	—
Globorotalia greenhornensis Morrow, n. sp.	—	—	C	—	—	—	—	—	—
Globorotalia subconica Morrow, n. sp.	—	—	—	—	—	—	—	C	—
Anomalina bentonensis Morrow, n. sp.	—	—	C	—	—	—	—	—	—
Anomalina sp.	—	—	C	—	—	—	—	—	—
Planulina kansasensis Morrow, n. sp.	—	—	—	—	—	—	—	C	—
OSTRACODA									
Cytherella kansasensis Morrow, n. sp.	—	—	—	—	—	—	—	P	—
Cytherella ? unilacuna Morrow, n. sp.	—	—	R	—	—	—	—	—	—
Cytherelloidea sp.	—	—	P	—	—	—	—	—	—
Cythereis alexanderi Morrow, n. sp.	—	—	—	—	—	—	—	R	—
Cythereis alexanderi abbreviata, n. var.	—	—	—	—	—	—	—	R	—
Cythereis niobrarensis Morrow, n. sp.	—	—	—	—	—	—	—	C	—
Cythereis subgracilis Morrow, n. sp.	—	—	—	—	—	—	—	R	—

[2] Explanation of symbols. C—common, R—rare, P—present.

the species in Kansas. For a detailed stratigraphic treatment of the Colorado group the reader is referred to the various county reports published by the Kansas Geological Survey.

DESCRIPTION OF SPECIES

FORAMINIFERA

Family LAGENIDAE

Genus LENTICULINA Lamarck, 1804

LENTICULINA KANSASENSIS Morrow, n. sp.
Plate 30, figures 23*a–b*.

Test involute, sides strongly convex, thickness almost half the diameter, periphery even, sharp; sutures limbate, curved, meeting the periphery obliquely, elevated into narrow, sharp ridges which die out before reaching the periphery, fusing at the center in a distinct boss; chambers 10 to 12 in final whorl; wall smooth except for the raised sutures; apertural face triangular, narrow, joining the preceding whorl in a sharp contact; aperture elliptical, at the apex of the apertural face. Diameter of holotype, 0.76 mm., thickness 0.34 mm.

Lenticulina kansasensis is distinguished from *L. sublaevis* by its stronger and more curved sutures, its slightly more compressed form, and its more elongate apertural face. The surface ornamentation is somewhat like that of *Cristellaria degolyeri* Plummer (**20,** p. 97, pl. 7, figs. 7*a–b*), a Midway species, but the Kansas species lacks a ragged keel and has several more chambers in the last whorl.

This species is very common in the basal Niobrara and has been found at several localities but apparently does not occur in other members.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75360.

LENTICULINA SUBLAEVIS Morrow, n. sp.
Plate 30, figures 14, 20*a–b*

Test relatively large, involute, sides equally and strongly convex, thickness about one-half the diameter, periphery simple, keeled or very sharply rounded; sutures limbate, gently curved, slightly raised, fusing at the center in a broad smoothly rounded boss; chambers 10 to 12 in final whorl; wall smooth except for the slightly raised sutures; apertural face triangular, convex, fusing into the outer wall of the preceding chamber; aperture circular, at the apex of the apertural face. Diameter of holotype 0.84 mm., thickness 0.44 mm.

There is some variation in the strength of the sutures, some specimens appearing almost smooth. *Lenticulina sublaevis* lacks the prominent, raised sutures shown by *L. kansasensis*, which makes the chambers less distinct and the sides of the test more nearly smooth. The sutures are usually not curved so strongly and meet the periphery at a higher angle than in our other species. *L. sublaevis* lacks the more complicated aperture of *Robulus*, thus making comparisons with species of this otherwise similar genus unnecessary.

This species is also restricted to the basal Niobrara where it is common at several localities.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75361.

Genus DENTALINA d'Orbigny, 1826

DENTALINA REFLEXA Morrow, n. sp.
Plate 29, figures 5, 20

Test elongate, slightly arcuate; successive chambers not increasing appreciably in length and but very little in diameter; initial end pointed, curving slightly reverse to the main curvature of the test; chambers few, distinct, inflated; sutures distinct, depressed, oblique, especially in early chambers; wall smooth. Length of holotype, 0.9 mm., thickness 0.16 mm.

This species is distinguished by the large pointed and slightly recurved proloculum. It compares rather closely with the Lower Cretaceous species *D. hamulifera* Reuss and *D. reflexa* Reuss (**9**). The point of the proloculum in *D. hamunlifera* recurves much more strongly and the

sutures are not so oblique. *D. reflexa* is more elongate and the chambers show a regular increase in length and diameter as the chambers are added.

Dentalina reflexa has been found only in the basal Niobrara where it is quite rare.

Holotype from sec. 32, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75362.

DENTALINA sp.
Plate 29, figure 6

A single specimen from the basal Niobrara, broken near the aperture is the only representative of this species. As this genus is apt to show considerable variation I hesitate to give it a name until more can be learned of it, though it is apparently undescribed. The test is very elongate, arcuate; sutures quite oblique and slightly depressed. The wall is ornamented with fine, parallel longitudinal costae.

Genus NODOSARIA Lamarck, 1812

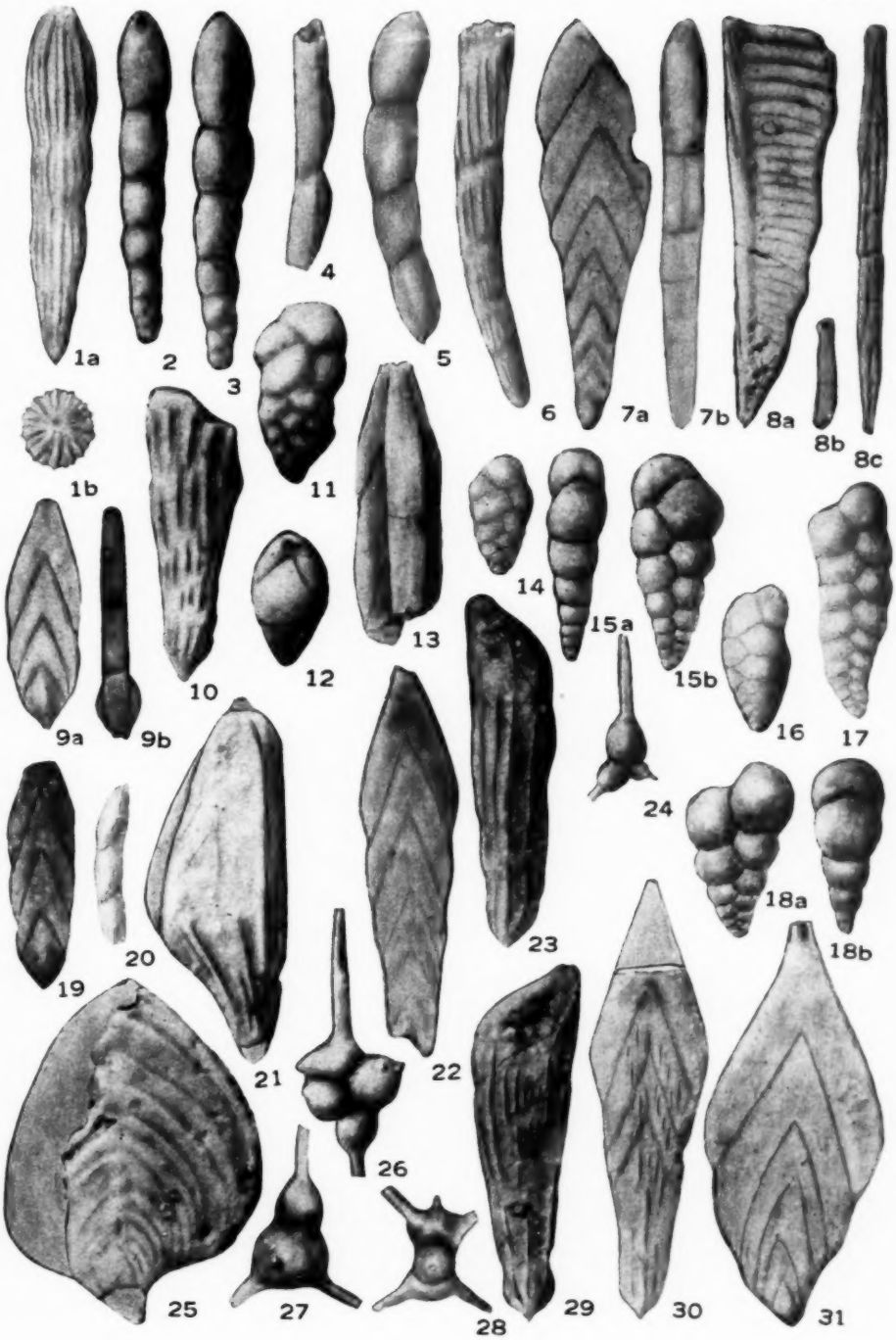
NODOSARIA ALTERNISTRIATA Morrow, n. sp.
Plate 29, figures 1*a–b*

Test elongate, tapering, initial end bluntly pointed; chambers few, slightly inflated, rather irregular in size; sutures slightly depressed, tending to be obscured by the surface ornamentation; wall ornamented by numerous weak, parallel, longitudinal costae which extend the full length of the test or are broken partially at the sutures; costae alternate stronger and weaker; aperture radiate, terminal. Length of holotype 0.75 mm., diameter 0.15 mm.

The costae on the holotype are easily overlooked and it was necessary to coat

EXPLANATION OF PLATE 29

FIGS. 1*a–b*—*Nodosaria alternistriata* Morrow, n. sp. *a*, Side view; *b*, apertural end view. ×66. (p. 190)
2, 3—*Nodosarella* Morrow, n. sp. Views of two individuals. ×50. (p. 197)
5, 20—*Dentalina reflexa* Morrow, n. sp. 5, Side view of holotype. 20, A smaller individual with the initial end broken away. ×50. (p. 189)
6—*Dentalina* sp. Side view of test with apertural end broken. ×66. (p. 190)
7*a–b*, 22—*Frondicularia dunbari* Morrow, n. sp. 7*a*, Front view; 7*b*, peripheral view. 22, Front view of a slightly different test. Figure 7 is the holotype. ×50. (p. 192)
8*a–c*—*Vaginulina niobrarensis* Morrow, n. sp. *a*, Side view; *b*, apertural end view; *c*, dorsal edge view. ×10. (p. 191)
9*a–b*, 19—*Frondicularia* sp. 9*a*, Front view; 9*b*, edge view. 19, Front view of a similar test. ×50. (p. 193)
10—*Vaginulina* cf. *texana* Cushman. Side view showing initial end and surface ornamentation. The apertural end is broken away. ×50. (p. 192)
11, 14, 16—*Bulimina* sp. Three individuals, probably representing at least two species. ×66. (p. 196)
12—*Bulimina reussi* Morrow, n. n. Front view, showing aperture. ×66. (p. 195)
13—*Frondicularia* sp. View of broken test, showing two chambers at apertural end. ×50. (p. 194)
15*a–b*, 17—*Gümbelina globifera* (Reuss). 15*a*, Edge view showing aperture; 15*b*, side view. 17, Side view of a more slender test. ×66. (p. 194)
18*a–b*—*Gümbelina globulosa* (Ehrenberg). *a*, Side view; *b*, edge view. ×66. (p. 194)
21—*Vaginulina subcomarginata* Morrow, n. sp. Side view, partly restored. ×50. (p. 192)
23—*Vaginulina knighti* Morrow, n. sp. Side view. ×50. (p. 191)
24, 26, 27, 28—*Hantkenina trituberculata* Morrow, n. sp. Views of four individuals. 24 and 26, Side views; 27 and 28, edge views. Figure 26 is the holotype. ×50. (p. 195)
25—*Flabellina cushmani* Morrow, n. sp. Side view, with outline partly restored. ×20. (p. 194)
29—*Vaginulina rectilateralis* Morrow, n. sp. Side view. The edges of the chambers which have been sketched, show as light lines when the test is immersed in liquid. ×50. (p. 191)
30—*Frondicularia aclis* Morrow, n. sp. Front view, restored. ×50. (p. 193)
31—*Frondicularia extensa* Morrow, n. sp. Front view. ×50. (p. 193)



Morrow, Cretaceous Foraminifera

the tests with an efflorescence of ammonium chloride to study them. *N. alternistriata* differs from *N. sceptrum* Reuss (**9**) from the Lower Cretaceous of Europe, which also shows an alternation of the costae, in having larger and fewer, less inflated chambers, and in lacking an apertural projection. *N. intercostata* Reuss is reported by Cushman (**33,** p. 31, pl. 4) from a higher horizon in the Cretaceous of Tennessee. This species has a large rounded proloculum with a spine at the initial end, the costae are stronger, the secondary ones being usually broken at the sutures, and the chambers are more inflated than in *N. alternistriata*.

Very rare in the basal Niobrara.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75363.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA NIOBRARENSIS Morrow, n. sp.
Plate 29, figures 8*a–c*

Test very large, flattened, broadest at the apertural end, dorsal edge straight, carinate, the carinae rising in pairs from the center of the dorsal side, passing downward and diverging slightly so as to terminate near the dorsal margin on opposite sides of the test; ventral edge rounded, slightly convex, distinctly lobed; chambers numerous, evenly spaced, nearly at right angles to the dorsal edge, curving slightly downward toward the ventral edge; sutures distinct, flat in young stages but becoming depressed toward the apertural end; wall smooth, initial end pointed; aperture slightly produced at the dorsal border, radiate. Length of holotype 6 mm., breadth 1.5 mm., thickness 0.45 mm.

Another smaller individual shows a slight curvature to the dorsal edge. *V. niobrarensis* resembles most closely *V. webbervillensis* Carsey (**21,** p. 39, pl. 2, fig. 7), a species from the Navarro formation of Texas, but is distinct from it and other species in outline, in the slight obliquity of the chambers and in the character of the dorsal edge.

Basal Niobrara. Only two specimens have been found.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75364.

VAGINULINA RECTILATERALIS Morrow, n. sp.
Plate 29, figure 29

Test small, elongate, flattened, broadest at the apertural end, edges nearly straight, gently tapering, tricarinate, apertural end slightly produced; sutures flush with surface, only moderately oblique, straight, parallel, chambers indistinct, obscured by surface ornamentation, not inflated, rather few, proloculum prominent, bulbous, pointed; surface bears in addition to the peripheral carinae about three long longitudinal costae on each side which pass onto the proloculum, and another group of faint, longitudinal, short, parallel costae which are arranged in sets on the surfaces of the later chambers; aperture slightly produced, radiate. Length of holotype 1 mm., breadth 0.28 mm., thickness 0.1 mm.

This species, which is believed to be undescribed, can not be confused with the other species of *Vaginulina* described here because of its distinctive surface ornamentation and outline. It resembles slightly a form figured by Cushman as *V.* cf. *simondsi* Carsey (**21,** p. 40, pl. 2, fig. 4) from a much higher horizon in Tennessee but in specific details they are quite different.

Basal Niobrara. Very rare and found only at the locality given below.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75365.

VAGINULINA KNIGHTI Morrow, n. sp.
Plate 29, figure 23

Test small elongate, moderately flattened, broadest near apertural end, edges nearly straight, very gently tapering, carinate, apertural end slightly produced; sutures feebly depressed, very oblique, slightly curved; chambers few, early ones tending to be obscured by the surface ornamentation, proloculum bulb-

ous, bluntly pointed; surface bearing a few long, widely spaced irregular costae, some of which continue onto the proloculum; aperture slightly produced, radiate. Length of holotype 1 mm., breadth 0.22 mm., thickness 0.14 mm.

Vaginulina knighti is distinguished from *V. rectilateralis* by being more elongate and not so flattened, by having slightly curved and more oblique sutures and coarser longitudinal costae, and in lacking the sets of fine parallel costae on the later chambers. These characters likewise distinguish the species from any other known to the writer. It differs from *V. simondsi* Carsey (**21,** p. 40, pl. 2, fig. 4) in having much shorter, less oblique chambers and lacks the regular fine ornamentation which covers the surface of the Texas species.

Very rare in the basal Niobrara, at the locality given below.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75366.

VAGINULINA SUBCOMARGINATA Morrow, n. sp.
Plate 29, figure 21

Test small, broad, flattened, broadest at about the middle, periphery bicarinate, dorsal edge straight, ventral edge sigmoid in side view, concave near the posterior end, becoming strongly convex above, apertural end broad; sutures flush with surface, very oblique, nearly straight; chambers not inflated, almost obscured by the ornamentation near the initial end; surface ornamented near the dorsal periphery on either side by a strong, straight costa which curves slightly inward near the aperture and in addition by several strong costae which radiate from the initial end for a short distance. Length of holotype about 1 mm., breadth as reconstructed 0.4 mm., thickness 0.14 mm.

A single specimen in the collection represents this species but it differs so strikingly from anything described that no hesitation is felt in giving it a name, despite the meager material. Species of *Vaginulina* commonly bear the radiate aperture at the end of a neck-like projection. The aperture opens into a bulbous cavity in this projection, which in turn is connected with the chamber by a short constricted opening. The specimen shows at the apertural end a small round opening indicating that the true aperture is broken away leaving the constricted opening below it visible. A small part of the initial tip and ventral edge is also wanting. This species is unique in having a straight dorsal margin and greatest breadth near or below the middle. The majority of species possessing the former are broadest near the apertural end, and those showing the latter usually have a marked curvature to the dorsal margin.

Basal Niobrara. Exceedingly rare.

Holotype from sec. 32, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75367.

VAGINULINA cf. TEXANA Cushman
Plate 29, figure 10

Vaginulina texana CUSHMAN, *1930,* Contr. Cushman Lab. Foram. Res., vol. 6, pt. 2, p. 30, pl. 4, figs. 2–4.

Test slightly flattened, tapering irregularly toward the initial end; initial chamber bulbous, pointed, later chambers becoming flattened, sutures obscure, surface ornamented with prominent discontinuous, longitudinal costae.

A single fragmentary specimen with the oral extremity wanting, from the basal Niobrara, lacks the necessary features to make specific assignment certain but the specimen seems to resemble *Vaginulina texana* Cushman more closely than any other species. *V. texana* was described from the Austin chalk of Texas.

Genus FRONDICULARIA Defrance, 1824

FRONDICULARIA DUNBARI Morrow, n. sp.
Plate 29, figures 7a–b, 22

Text elongate, tapering evenly with greatest width near the base of the last chamber, much compressed, faces nearly parallel; due to the curvature of the outer margin of the chambers the periphery is slightly scalloped. Periphery truncate,

sometimes becoming rounded in the last chambers; initial end small, bluntly pointed; chambers distinct, of uniform shape, evenly spaced, apertural end extended; sutures distinct, usually slightly depressed, nearly straight; wall smooth except for the slight depression of the sutures; aperture radiate, at the end of a slender protuberance. Length 1.15 mm., breadth 0.36 mm., thickness 0.14 mm.

In outline this species shows a striking resemblance to *F. archiaciana* d'Orbigny (**4**, p. 20, pl. 1, figs. 34–36) but they may be distinguished by the raised and sigmoidally curved sutures of the latter. The evenly tapered and scalloped sides and the slightly depressed sutures are believed to distinguish *F. dunbari* from other described species. The several specimens in the collection show this species to be quite constant in its characters.

Fairly common at several localities but restricted to the basal Niobrara.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75368.

FRONDICULARIA EXTENSA Morrow, n. sp.
Plate 29, figure 31

Test broadly elongate, greatest breadth above but near the middle, strongly compressed, faces nearly parallel, periphery broadly rounded in edge view, slightly scalloped in outline, initial end bluntly pointed; chambers distinct, rather few in number, of uniform shape and spacing, apertural end extended; sutures distinct, slightly depressed, nearly straight; wall smooth except for the slight depression of the sutures; aperture radiate, at the end of a slender protuberance; proloculum slightly inflated. Length 1.1 mm., breadth 0.5 mm.

This species is readily distinguished from *F. dunbari* by its much greater breadth compared to the length, fewer chambers, and general outline. No other described species has been encountered which resembles it closely.

From the basal Niobrara. Found only at the locality given below.

Holotype from sec. 32, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75369.

FRONDICULARIA ACLIS Morrow, n. sp.
Plate 29, figure 30

Test elongate tapering, greatest breadth toward the apertural end, much compressed, faces nearly parallel, periphery truncate, initial end bluntly pointed; chambers rather indistinct, of nearly uniform shape, apertural end bluntly pointed; sutures distinct, slightly depressed, nearly straight, the depression of the sutures at the apex extended so as to give the appearance of a faint longitudinal furrow; wall covered with obscure longitudinal lirae; proloculum bulbous, smooth or ornamented by one or more of the lirae which may continue onto it. Length about 1.2 mm., breadth 0.35 mm.

The figured specimen which has the apertural end broken, and another somewhat larger individual showing the aperture but lacking the initial end, are the only specimens of this type in the collection. The liration alone is sufficient to make this species easily distinguished from the other species of *Frondicularia* given in this paper. It differs from *F. gracilis* Franke (**19**, p. 50, pl. 4, fig. 9) and *F. angusta* Nillson (**2**, p. 11, pl. 9, fig. 22*a*) in its much more subdued longitudinal ornamentation and more angular outline.

Basal Niobrara. Very rare.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75370.

FRONDICULARIA sp.
Plate 29, figures 9*a–b*, 19

A few very small specimens have been found which are quite distinct from the other species of this genus. Their small size and relatively large proloculum suggests that they are megalospheric forms but until more material can be studied it seems advisable to leave this group unnamed.

Frondicularia sp. occurs sparingly in the basal Niobrara.

FRONDICULARIA sp.
Plate 29, figure 13

A single fragmentary specimen having a tricarnate transverse section undoubtedly belongs to the interesting group of *Frondicularia*. Reuss and d'Orbigny have described and figured such forms from the Cretaceous of Europe but to the writer's knowledge none have been reported in this country. The characters agree with typical *Frondicularia* except in the three-fold symmetry about the long axis of the test. This difference seems to be an important one and suggests the unadvisability of referring such forms to *Frondicularia*. A new genus would have to be erected to receive them if they were taken from *Frondicularia*. Only the last two chambers are visible in the specimen figured. Our form has thicker chambers and less prominent sutures than *F. tricarinata* d'Orbigny (**4**).

Genus FLABELLINA d'Orbigny, 1839
FLABELLINA CUSHMANI Morrow, n. sp.
Plate 29, figure 25

Test large, broad, much compressed, greatest breadth near the base, sides strongly convex in outline, rounded in edge view; chambers distinct, numerous, quite uniform in shape, the very early ones showing distinct coiling; sutures distinct, very slightly depressed, bearing at their apex a low, rounded elevation; wall smooth except for the depressed sutures and low elevations at the apex. Length about 2.15 mm., breadth about 2 mm.

The species resembles *F. glabrons* (Cushman **33,** pp. 34–35, pl. 4, figs. 12*a–b*) in outline, but differs from it in having much more numerous chambers and depressed sutures. It is also similar in outline to *F. microdisca* (Reuss **8,** p. 196, pl. 5, fig. 4) but this species likewise has a smooth wall. The writer had opportunity to examine typical European *Flabellina rugosa* d'Orbigny (**4,** p. 23, pl. 2, figs. 4, 5, 7) which differs from our species in having sharp, raised sutures bearing an auxiliary loop at their apex which corresponds in position and outline to the low rounded elevations shown in *Flabellina cushmani*. This large form seems to belong to *Flabellina* rather than *Frondicularia*. The aperture and proloculum are broken away, but from the slightly unsymmetrical curvature of the sides near the base and the coiled early chambers the initial end can be reconstructed with fair assurance.

Very rare in the basal Niobrara at the locality given below.

Holotype from sec. 32, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75371.

Family HETEROHELICIDAE

Genus GÜMBELINA Egger, 1899
GÜMBELINA GLOBULOSA (Ehrenberg)
Plate 29, figure 18*a–b*

Textularia globulosa Ehrenberg, *1838*, Abhandl. k. ak. Wiss. Berlin, p. 135, pl. 4, fig. *b*.

Test short, V-shaped, biserial, widening rapidly; chambers nearly spherical, three to four on each side; aperture at the base of the last chamber, semilunar; surface smooth. Length of figured specimen 0.5 mm., breadth 0.3 mm.

This species differs from *G. globifera* (Reuss) in the smaller ratio of width to height, fewer chambers and straighter sides.

G. globulosa occurs in great abundance throughout the Colorado group and has also been found in the upper Pierre of Kansas and is reported from many of the Upper Cretaceous areas of the world.

GÜMBELINA GLOBIFERA (Reuss)
Plate 29, figures 15*a–b*, 17

Textularia globifera Reuss, *1860* Sitz. k. Ak. Wiss. Wien, vol. 40. p. 232, pl. 13, figs. 7*a–b*, 8.

Test elongate, V-shaped, biserial, with sides slightly curved; six to nine nearly spherical chambers on each side, enlarging more gradually than in *G. globulosa;* aperture at base of last chamber, similunar. Length up to 0.7 mm.

This species occurs with *G. globulosa* in Kansas and might be considered as a variation of this species. At present *G. globulosa* and *G. globifera* appear to have little stratigraphic significance as they are reported in most Upper Cretaceous faunas.

Genus EOUVIGERINA Cushman, 1926

EOUVIGERINA GENEAE Morrow, n. sp.

Plate 30, figures 13, 16, 17, 19

Test elongate, slightly tapering, greatest breadth toward apertural end; early chambers biserial, tending to become uniserial in the last three or four chambers; chambers inflated rounded; sutures distinct, depressed; wall roughened by minute spines; aperture rounded, terminal, at the end of a short cylindrical neck. Length up to 0.56 mm., breadth 0.14 mm.

This species differs from the Taylor species *E. gracilis* Cushman (**22,** p. 5, pl. 1, figs. 2*a–c*) in the absence of a phialine lip around the aperture and in the much more pronounced uniserial arrangement of the later chambers which gives our species a nodosarian aspect. *E. hispida* Cushman (**33,** p. 45, pl. 7, figs. 12, 13) from the Selma has a spine at the initial end and is predominately biserial.

Eouvigerina geneae is one of the most common species in the basal Niobrara and was noted in samples from several localities. It has not been found in other members.

Holotype from SE. $\frac{1}{4}$, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75372.

Family HANTKENINIDAE

Genus HANTKENINA Cushman, 1924

HANTKENINA TRITUBERCULATA Morrow, n. sp.

Plate 29, figures 24, 26, 27, 28

Test small, almost planispiral; chambers globular in all stages, usually nearly spherical, in last whorl possessing from one to three long, distal, tubular extentions sometimes more than twice the length of the diameter of the globose part of the chamber. If only one tube occurs it lies in the median plane, if two they lie one on either side of this plane, and if three occur one is median and the others paired beside it. The tubes join the bulbous chamber quite abruptly with very little flaring. There are usually three chambers in the last whorl though occasionally four. Length of longest specimen 0.75 mm., diameter of last chamber 0.16 mm.

This species closely resembles the young of *H. multispinata* Cushman and Wickenden (**32,** p. 40, pl. 6, figs. 4–6) except for its more nearly spherical chambers. The Kansas specimens are doubtless adult forms for individuals similar to those figured are very common locally. *H. multispinata* differs from *H. trituberculata* in the possession of polyhedral chambers and considerably shorter spines. The chambers of the Kansas species are similar in form to *H. cenomana* (Schako) but in the latter there are four in the last whorl, each bearing a single spine except the last which lacks the tubular process. In its development and stratigraphic position *H. trituberculata* represents an intermediate stage between *H. cenomana* (**15,** p. 161, pl. 4, figs. 3–5) and *H. multispinata*.

The species is rather common in the Hartland shale of the Greenhorn formation and in the Smoky Hill member of the Niobrara.

The holotype is from the Hartland shale, sec. 31, T. 21 S., R. 22 W., Hodgeman County, Kansas. U. S. National Museum, No. 75373.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA REUSSI Morrow, n. n.

Plate 29, figure 12

Bulimina ovulum REUSS, *1845,* Verstein. Böhm. Kreide, pt. 1, p. 37, pl. 8, fig. 57; pl. 13, fig. 73. (Not *B. ovula* D'ORBIGNY, 1839)

Test small, ovate, globular, subcircular in transverse section with greatest breadth above the middle, tapering evenly to a rather sharply rounded initial

end; chambers triserial throughout, obscure, enlarging very rapidly in size as they are added; sutures very slightly depressed; wall smooth, very finely perforate; aperture small, subterminal. Height 0.28 mm., breadth 0.16 mm.

This very small species is moderately common in the basal Niobrara and is easily distinguished from its associates. The very slight inflation of the chambers makes the exterior appear quite smooth. The writer examined metatypes of this European species and found that they were remarkably like our specimen, more so than Reuss' figures would imply. Doctor Cushman called the writer's attention to the fact that *B. ovula* Reuss was preoccupied. D'Orbigny (**3,** p. 51, figs. 10, 11) described a Tertiary species from the west coast of South America, which he named *B. ovula*, six years before Reuss' work appeared.

BULIMINA sp.

Plate 29, figures 11, 14, 16

Many specimens of *Bulimina* have been found in the basal Niobrara. There is a rather wide range of variation shown among them though they seem to fall into two general groups. The first, represented by figures 11 and 14, has its chambers noticeably inflated and rather irregularly arranged; the other group shows a more regular triserial arrangement of the chambers producing a triangular cross-section. As it is difficult in most cases to determine the nature of the aperture, it seems advisable to postpone their description until more and better material can be studied.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA TEGULATA Reuss

Plate 30, figures 21*a–b*

Bolivina tegulata REUSS, *1851,* Haidinger's Nat. Abhandl., vol. 4, p. 29, pl. 4, fig. 12.

Test elongate, tapered as viewed from side, edges nearly parallel and straight in front view, broadest near last formed chamber, periphery rounded; chambers numerous, distinct, slightly inflated, broader than high; sutures distinct, depressed, nearly straight; wall smooth, finely perforate; aperture elongate, subterminal. Length 0.6 mm., breadth 0.13 mm.

Specimens from the Austin chalk of Texas are indistinguishable from our material and topotypes of the European material are likewise very similar. The high position of the aperture indicates that this species is becoming rather close to *Loxostomum.*

Bolivina tegulata has been found only in the basal Niobrara.

Family ELLIPSOIDINIDAE

Genus PLEUROSTOMELLA Reuss, 1860

PLEUROSTOMELLA NITIDA Morrow, n. sp.

Plate 30, figures 22*a–b*

Test elongate, somewhat compressed, front view narrow, the sides nearly straight and tapering slightly; chambers few, inflated, later ones rather elongate, apertural end of the last formed chambers somewhat extended, face appearing sigmoidally curved as seen from side view; sutures distinct, depressed; wall smooth, finely perforate; aperture subterminal elliptical, apparently not toothed. Length 0.58 mm., breadth 0.13 mm., thickness 0.12 mm.

Our species was compared with specimens of *P. subnodosa* Reuss (**8,** p. 204, pl. 8, figs. 2*a–b*) from the European type locality. It differs from the latter in being smaller and in the greater obliquity of the sutures which produces a more striking alternation of the chambers. Doctor Cushman reports *P. subnodosa* Reuss from the Navarro of Texas.

This attractive species is quite rare, only a half dozen specimens having been found and most of them are from the locality given below. A few fragments and crushed specimens were noted in basal Niobrara samples which quite possibly belong to this species.

Holotype from Hartland shale member of the Greenhorn formation, sec., 31, T. 21 S., R. 22 W., Hodgeman County,

Kansas. U. S. National Museum, No. 75374.

Genus NODOSARELLA Rzehak, 1895

NODOSARELLA, n. sp.
Plate 29, figures 2, 3

Test very elongate, straight or nearly so, tapering very slightly; chambers inflated; first few showing a biserial arrangement, later ones uniserial, elongate, circular in cross section; apertural end of the last formed chamber somewhat extended, initial tip rounded; sutures distinct, depressed; wall smooth, finely perforate; aperture small subterminal, semielliptical. Length of largest specimen 1 mm., diameter of last chamber 0.18 mm.

There seems to be nothing described which closely resembles this species. Doctor Cushman has found it ranging through the Austin chalk in Texas and has it described in manuscript. In Kansas it has been found only in the basal Niobrara.

Family ROTALIIDAE

Genus VALVULINERIA Cushman, 1926

VALVULINERIA INFREQUENS Morrow, n. sp.
Plate 30, figures 3*a–c*

Test trochoid, compressed, dorsal side moderately convex, periphery rounded, all of the whorls visible from the dorsal side, only the last on the ventral side; chambers moderately inflated, increasing gradually in size as added, last chamber in adult much larger and more inflated ventrally, tending to overhang; six chambers in final whorl; sutures distinct, depressed, curving strongly outward and backward; wall smooth, perforate; aperture ventral, elongate-extending along the base of the last chamber to the prominent umbilical area, covered by a low lip. Height of holotype 0.36 mm., breadth 0.16 mm.

This species is distinguished by its small, glassy, markedly perforate test with its much enlarged final chamber. It is rare but the few specimens in the collection show very little variation from the holotype. This species is quite similar to *Valvulineria araucana* (d'Orbigny) a recent species. It is like *V. wilcoxensis* Cushman and Ponton (**35,** p. 70, pl. 9, figs. 6*a–c*) in the number and shape of the chambers but the latter is nearly planispiral and quite evolute.

Valvulineria infrequens has been found only in the basal Niobrara.

Holotype from SE. ¼, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75375.

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA NITIDA (Reuss)
Plate 30, figures 1*a–c*

Rotalina nitida REUSS, *1845,* Geogn. Skizz. 2, p. 214; Verstein. Bohm. Kreide, pt. 1, p. 35, pl. 8, fig. 52.

Test small, trochoid; ventral side very convex, periphery broadly rounded, dorsal side gently convex, or nearly flat; chambers few, four to six in last whorl, slightly inflated. Height 0.25 mm., breadth 0.18 mm.

The only species with which it might be confused is *Gyroidida lenticula* (Reuss) as they are the same size and similar in many respects. They are distinguished by the much greater breadth and the more broadly rounded periphery of *G. nitida.*

The writer had the opportunity to study metatypes of *G. nitida* and found that they were apparently indistinguishable from the Kansas specimens. This species is moderately common in the basal Niobrara.

GYROIDINA LENTICULA (Reuss)
Plate 30, figures 5*a–c*

Rotalina lenticula REUSS, *1845,* Verstein. Bohm. Kreide, pt. 1, p. 35, pl. 12, fig. 17.

Test small, almost equally biconvex, moderately compressed, peripheral margin narrowly rounded; chambers five to six in final whorl; sutures very slightly depressed, curving gently backward; wall smooth, finely perforate. Height 0.26 mm., breadth 0.12 mm.

This species is distinguished from *Gyroidina nitida* (Reuss) by its narrowly

rounded periphery, nearly equally biconvex test, and smaller breadth.

Metatypes of this species were also examined and likewise found to be indistinguishable from the Kansas material. In neither this species nor *G. nitida* was the writer able to definitely recognize the aperture, but it is probably at the base of the last chamber, near the umbilicus.

As in the case of *Gyroidina nitida*, *G. lenticula* has been found only in the basal Niobrara in Kansas.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA CRETACEA d'Orbigny

Plate 30, figures 7, 8, 10*a–b*

Globigerina cretacea D'ORBIGNY, *1840*, Mem. Soc. Geol. France, ser. 1, vol. 4, p. 34 pl. 3, figs. 12–14.

Test trochoid, rotaliform, two and one-half to three whorls, all visible from dorsal side, last whorl visible from ventral side; chambers spherical, about five in the last whorl, increasing rather rapidly in size. Wall perforate; sutures strongly depressed; aperture opening into umbilical depression from margin of last chamber.

Young stages of *G. cretacea* resemble the species *G. bulloides*, to which they have often been referred by earlier authors.

G. cretacea is the most common species of the Cretaceous foraminifera. It is reported from most Upper Cretaceous areas of the world.

Genus HASTIGERINELLA Cushman, 1927

HASTIGERINELLA SIMPLEX Morrow, n. sp.

Plate 30, figures 6*a–b*

Test moderately trochoid; chambers in the early portion globular, the penultimate chamber becoming slightly elongate and the final chamber strongly elongate

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EXPLANATION OF PLATE 30

FIGS.

1*a–c*—*Gyroidina nitida* (Reuss). *a*, Ventral view; *b*, peripheral view; *c*, dorsal view. ×66. (p. 197)

2*a–b*, 12*a–c*, 15*a–c*—*Planulina kansasensis* Morrow, n. sp. 2*a*, Ventral view; 2*b*, dorsal view. 12*a*, Dorsal view; 12*b*, ventral view; 12*c*, peripheral view. 15*a*, Dorsal view; 15*b*, peripheral view; 15*c*, ventral view. Figure 15 is the holotype. ×50. (p. 201)

3*a–c*—*Valvulineria infrequens* Morrow, n. sp. *a*, Dorsal view; *b*, peripheral view; *c*, ventral view. ×50. (p. 197)

4*a–b*—*Anomalina bentonensis* Morrow, n. sp. *a*, Side view; *b*, peripheral view. ×50. (p. 201)

5*a–c*—*Gyroidina lenticula* (Reuss). *a*, Ventral view; *b*, peripheral view; *c*, dorsal view. ×66. (p. 197)

6*a–b*—*Hastigerinella simplex* Morrow, n. sp. *a*, Dorsal view; *b*, ventral view. ×50. (p. 198)

7, 8, 10*a–b*—*Globigerina cretacea* d'Orbigny. 7, 8, 10*a*, Dorsal views; 10*b*, ventral view. ×150. (p. 198)

9*a–b*—*Anomalina* sp. *a*, Dorsal view; *b*, peripheral view. ×50. (p. 201)

11*a–c*, 18—*Globorotalia subconica* Morrow, n. sp. 11*a*, Ventral view; 11*b*, dorsal view; 11*c*, peripheral view. 18, Ventral view of a smaller individual showing the development of a lip at the edge of the last chamber. ×66. (p. 200)

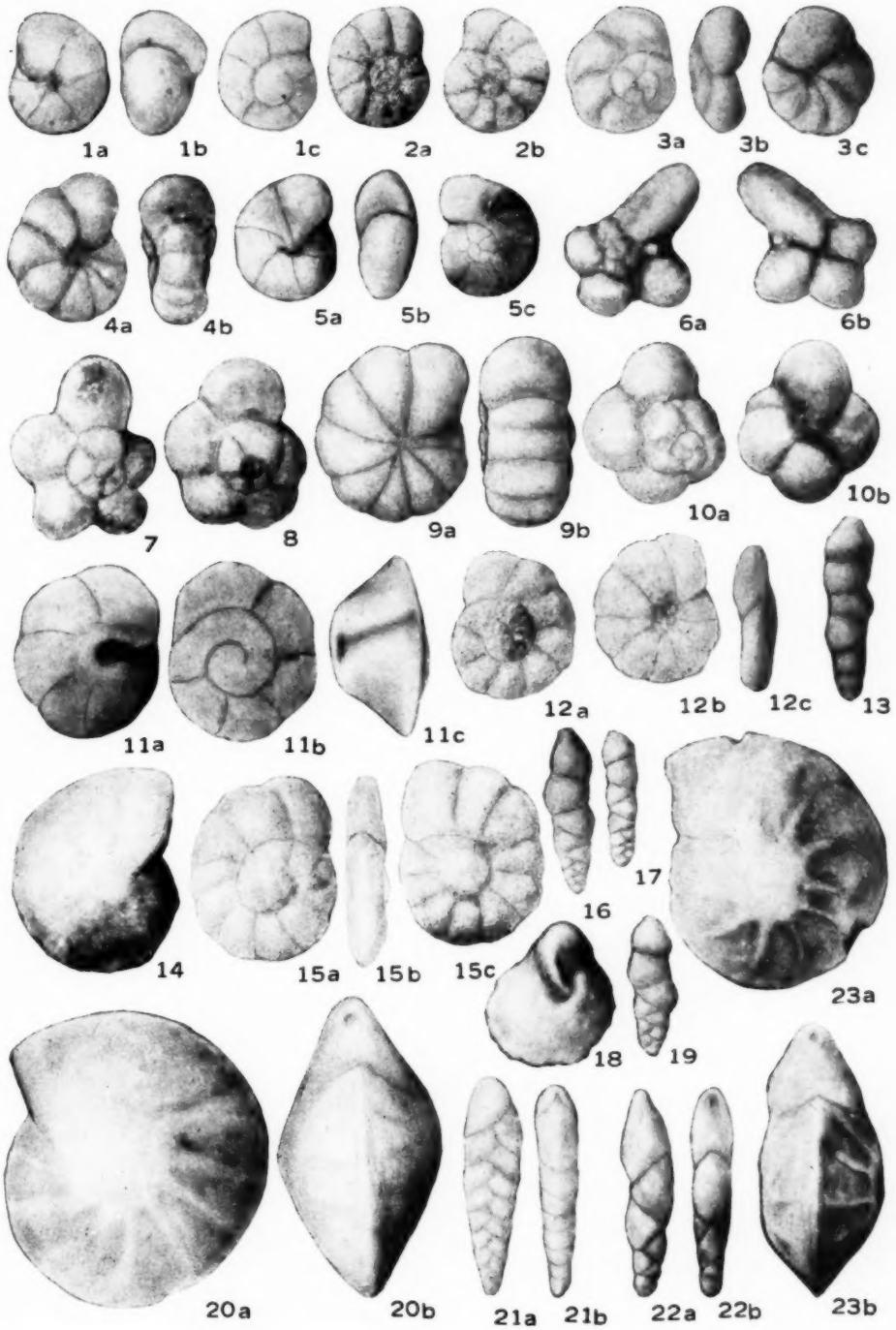
13, 16, 17, 19—*Eouvigerina geneae* Morrow, n. sp. Views of four individuals, showing variations. Figure 13 is an edge view. Figure 16 is the holotype. ×50. (p. 195)

14, 20*a–b*—*Lenticulina sublaevis* Morrow, n. sp. 14, Side view; 15*a*, side view; 15*b*, peripheral view. Figure 15 is the holotype. ×50. (p. 189)

21*a–b*—*Bolivina tegulata* (Reuss). *a*, Side view; *b*, edge view, showing aperture. ×50. (p. 196)

22*a–b*—*Pleurostomella nitida* Morrow, n. sp. *a*, Side view; *b*, edge view, showing aperture. ×50. (p. 196)

23*a–b*—*Lenticulina kansasensis* Morrow, n. sp. *a*, Side view; *b*, peripheral view. ×50. (p. 189)



Morrow, Cretaceous Foraminifera

and evenly rounded at the end; chambers about four is the final whorl; sutures distinct, moderately depressed; wall finely spinose; aperture indistinct. Diameter 0-50 mm., thickness about 0.2 mm.

It is with some hesitation that this species is excluded from *Globigerina* for if the final chamber were lacking it would certainly be placed in this genus. However as *H. simplex* falls so nicely into the evolutionary series of the genus I am considering it as distinct from *Globigerina*. This species seems to be even more primitive than *H. moremoni* Cushman (**34,** p. 86, pl. 11, figs. 1–3) which shows the elongation of the chambers at an earlier stage and an expansion of the later chambers toward the tip. It seems probable that this species represents very nearly the lowest limit of the genus. The Tertiary species *H. eocanica* Nuttall (**27,** p. 376, pl. 50, figs. 9–11) has bluntly rounded chambers but, as other species of the genus, differs in the earlier development of the elongated chambers.

Hastigerinella simplex has been found only in the Greenhorn formation. This species has been found in samples from several Hartland shale localities, but is not known to occur in other members.

Holotype from sec. 31, T. 21 S., R 22 W., Hodgeman County, Kansas. U. S. National Museum, No. 75376.

Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA CUSHMANI Morrow, n. sp.

Plate 31, figures, 2*a–b*, 4*a–b*

Test trochoid, dorsal side moderately convex with chambers flattened or slightly inflated, dorsal sutures roundly curving, producing a scalloped periphery; the anterior margin sometimes raised slightly, ventral side strongly convex with the chambers strongly inflated, sutures deeply grooved and nearly radiate; only the last whorl, of four to six chambers visible, the periphery sharply rounded and thickened into a narrow rim. Diameter of larger figured specimen 0.7 mm., thickness 0.25 mm.

This species most closely resembles *Globoratalia membranacea* (Ehrenberg **7,** pl. 25, 1*a*, fig. 41; pl. 26, fig. 43) which is an index fossil to the Velasco shale. Our species is larger, has the chambers more inflated, and shows more of an early *Globigerina* stage than *G. membranacea*. It is restricted to the Greenhorn formation where it is associated with *Globigerina cretacea*, *Globorotalia greenhornensis* and *Globorotalia multiloculata*, from which it is distinguished by having fewer chambers and less convex ventral side with more deeply depressed sutures.

Quite common at several localities in the Hartland member of the Greenhorn formation. It has not been noted outside this member.

Holotype from sec. 31, T. 21 S., R. 31 W., Hodgeman County, Kansas. U. S. National Museum, No. 75377.

GLOBOROTALIA GREENHORNENSIS

Morrow, n. sp.

Plate 31, figures 1*a–c*

Test trochoid, biconvex, dorsal side distinctly convex, ventral side strongly convex; periphery slightly scalloped, chambers numerous, eight or nine in final whorl, dorsal side flattened, bordered by a thickened, slightly elevated margin which curves forward from the edge of the preceding chamber to the spiral suture, chambers seen from the ventral side inflated, extended in the direction of the axis of coiling producing a deep, steepsided umbilical area; sutures on the ventral side strongly depressed, curving gently backward; periphery acute, wall finely perforate; aperature umbilical at base of last chamber. Diameter 0.66 mm., thickness 0.22 mm.

The characters of *G. greenhornensis* are distinctive and quite constant, making it very easy to distinguish from other species with which it is associated.

This species is very abundant locally and apparently restricted to the Greenhorn formation.

Holotype from the Hartland shale member, sec. 31, T. 21 S., R. 22 W.,

Hodgeman County, Kansas. U. S. National Museum, No. 75378.

GLOBOROTALIA ? MULTILOCULATA
Morrow, n. sp.
Plate 31, figures 3*a–b*, 5*a–b*

Test trochoid, biconvex, compressed; dorsal side strongly convex, ventral side moderately convex; chambers numerous, seven to nine in final whorl, very distinct, inflated, narrowly rounded but not keeled at their periphery, tending in the last whorl to be produced ventrally in the direction of the axis of coiling; umbilical area large and rather deep; sutures strongly depressed; wall finely perforate. Diameter 0.7 mm., thickness 0.3 mm.

This species seems to be the most primitive of the three species of *Globorotalia* here described from the Greenhorn formation. It is evidently very close to *Globigerina*. Since the other two species are definitely not *Globigerina*, and yet all three species are obviously quite closely related, it seems best to consider this species in the same genus. There is a suggestion of the development of the keeled periphery of *Globorotalia* in the sharply rounded margin of the chambers appearing in edge view, about intermediate between *Globorotalia greenhornensis* and typical *Globigerina*. The similar aspect of the ventral side in these species is also striking. *G. multiloculata* is quite common locally in the Greenhorn formation associated with the two species just described. It is easy to distinguish because of its numerous chambers and globogerine aspect with a narrowed periphery.

Holotype from the Hartland member, Greenhorn formation, sec. 31, T. 21 S., R. 22 W., Hodgeman County, Kansas. U. S. National Museum, No. 75379.

GLOBOROTALIA SUBCONICA Morrow, n. sp.
Plate 30, figures 11*a–c*, 18

Test planoconvex, subconical, dorsal side slightly convex or flat, the sides of the cone flare near the periphery giving them a gently concave profile, umbilical cavity at the apex, small but distinct, periphery keeled or very sharply rounded; chambers indistinct, about six in last whorl; sutures on ventral side may be slightly depressed but are not depressed on dorsal side, curved; wall smooth finely perforate; aperture elongate, extending along the inner edge of the last chamber. Height of holotype 0.36 mm., thickness 0.18 mm.

This species seems to be intermediate between the larger species *G. micheliniana* (d'Orbigny) (**4,** p. 31, pl. 3, figs. 1–3) which has a relatively higher and straighter sided cone, and an undescribed Texas species in which the cone is lower

EXPLANATION OF PLATE 31

FIGS. 1*a–c*—*Globorotalia greenhornensis* Morrow, n. sp. *a*, Dorsal view; *b*, peripheral view; *c*, ventral view. ×50. (p. 199)

2*a–b*, 4*a–b*—*Globorotalia cushmani* Morrow, n. sp. 2*a*, Dorsal view; 2*b*, ventral view. 4*a–b*, Views of a larger test with reverse coiling. ×50. (p. 199)

3*a–b*, 5*a–b*—*Globorotalia? multiloculata* Morrow, n. sp. 3*a*, Dorsal view; 3*b*, ventral view. 5*a–b*, Similar views of another individual. Figure 3 is the holotype. ×50. (p. 200)

7*a–b*—*Cytherelloidea* sp. *a*, Dorsal view; *b*, side view. ×50. (p. 202)

8*a–c*—*Cythereis alexanderi abbreviata* Morrow, n. var. *a*, Dorsal view; *b*, side view; *c*, ventral view. ×50. (p. 203)

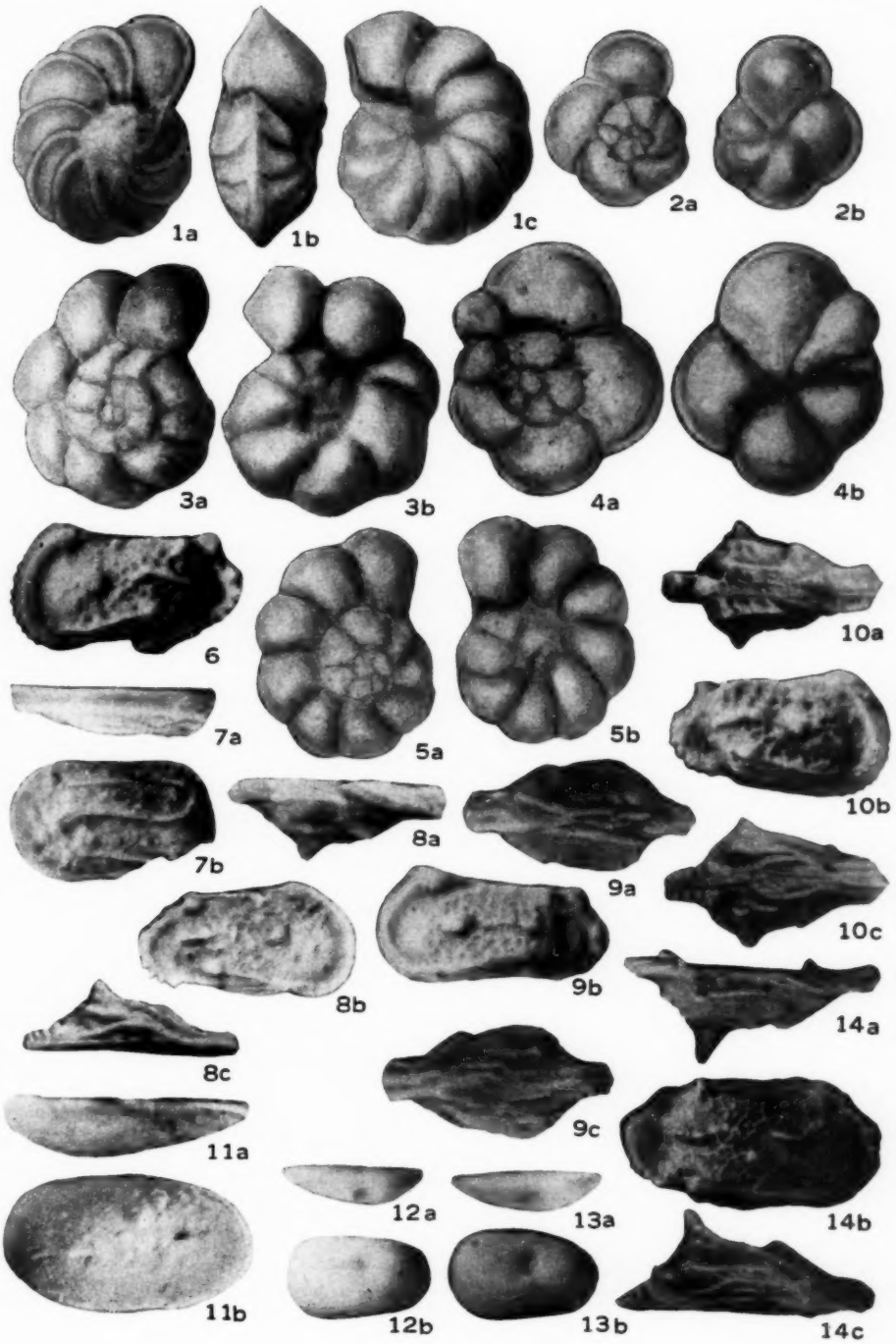
9*a–c*—*Cythereis subgracilis* Morrow, n. sp. *a*, Dorsal view; *b*, side view; *c*, ventral view. ×50. (p. 204)

6, 10*a–c*—*Cythereis niobrarensis* Morrow, n. sp. 10*a*, Dorsal view; 10*b*, side view; 10*c*, ventral view. 6, Side view of another individual. ×50. (p. 203)

11*a–b*—*Cytherella kansasensis* Morrow, n. sp. *a*, Dorsal view; *b*, side view. ×50. (p. 202)

12*a–b*, 13*a–b*—*Cytherella? unilacuna* Morrow, n. sp. 12*a*, Dorsal view; 12*b*, side view of the holotype. 13*a–b*, Similar views of another valve, having a slightly different outline. ×50. (p. 202)

14*a–c*—*Cythereis alexanderi* Morrow, n. sp. *a*, Dorsal view; *b*, side view; *c*, ventral view. ×50. (p. 203)



Morrow, Cretaceous Foraminifera and Ostracoda

than *G. subconica*, with a very sharply keeled periphery. The Ripley form, *Gyroidina alabamensis* Sandidge (**37,** pp. 283–284) differs from our species in being less compressed and in having convex ventral sides viewed from the side.

This species has been found only in the basal Niobara where it is relatively common.

Holotype from sec. 32, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75380.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA BENTONENSIS Morrow, n. sp.
Plate 30, figures 4*a–b*

Test small, nearly symmetrical, slightly involute, periphery broadly rounded, earlier whorls partly exposed on both sides at the center; chambers inflated, increasing rather rapidly in size as added, quite uniform in shape, numbering seven to nine in last whorl; sutures strongly impressed, usually curving backward as they pass over the periphery; wall conspicuously perforate; aperture peripheral, passing onto the dorsal side. Diameter of holotype 0.4 mm., thickness 0.2 mm.

This species differs from any known to the writer by being more nearly planispiral and bilaterally symmetrical and in having a broad and evenly rounded periphery.

This species has been found only in the Greenhorn formation where it is common locally.

Holotype from the Hartland shale member of the Greenhorn formation, sec. 31, T. 21. S., R. 22 W., Hodgeman County, Kansas. U. S. National Museum No. 75381.

ANOMALINA sp.
Plate 30, figures 9*a–b*

A few specimens of *Anomalina* have been found which appear to be distinct from *A. bentonensis* but they have shown considerable variation and until a larger collection can be studied it seems advisable to leave the species undescribed. The specimen figured shows the dorsal side completely involute with a part of the earlier whorls visible on the ventral side. The chambers are inflated, very broadly rounded across the periphery and increase in size very gradually. Another specimen shows these same characters but the shell is strongly trochoid with the early whorls conspicuous on the ventral side.

This species is likewise restricted to the Greenhorn formation.

Genus PLANULINA d'Orbigny, 1826

PLANULINA KANSASENSIS Morrow, n. sp.
Plate 30, figures 2*a–b*, 12*a–c*, 15*a–c*

Test much compressed, dorsal and ventral sides nearly flat, slightly trochoid and involute; periphery rounded, chambers numerous, eight to ten in final whorl, all chambers exposed on the dorsal side, partially covered on the ventral side; sutures distinct between the later chambers, slightly depressed, curved outward and backward; central area on both sides covered by a calcareous deposit varying in thickness from a film to a thick rounded plug, which may be transparent showing the covered chambers; wall smooth, perforate; aperture obscure, extending along the base of the last chamber onto the ventral side. Diameter up to 0.52 mm., thickness 0.12 mm.

It is referred to *Planulina* with some doubt, though it seems to agree in general with the characters of the genotype, *Planulina ariminensis* d'Orbigny, (**1,** p. 280, pl. 14, figs. 1–3) and with figures and description of topotypes given by Cushman (**29,** p. 102, pl. 15).

The type species is larger, more coarsely perforate and the sutures curve strongly, meeting the periphery at a very low angle. It differs from various similar species described under *Truncatulina*, *Gyroidina* and *Anomalina* in being almost evolute, very compressed with nearly flat sides, and in the abundance of the secondary calcareous filling on the central areas. A larger species described by Carsey (**21,** p. 47, pl. 6, figs. 1*a–b*) as

Anomalina taylorensis is in some respects similar to our species. Mrs. Carsey reports a smaller form in the Austin which may prove to be the same as *P. kansasensis*. *Anomalina taylorensis* is described as having raised sutures.

This species has been found only in the basal Niobrara where it is quite common at a number of localities.

Holotype from SE. $\frac{1}{4}$, sec. 12, T. 12 S., R. 17 W., Ellis County, Kansas. U. S. National Museum, No. 75382.

OSTRACODA

Family CYTHERELLIDAE

Genus CYTHERELLA Jones, 1848

CYTHERELLA KANSASENSIS Morrow, n. sp.
Plate 31, figures 11*a–b*

Carapace in side view elliptical, dorsal and ventral edges gently convex and curving regularly into the posterior and anterior ends. As seen in dorsal view the posterior end of the right valve is bluntly rounded and the anterior end subacute, the greatest thickness being posterior to the middle; greatest overlap at the posterior end; anterior end slightly thickened at the periphery; surface smooth. Length 0.7 mm., height 0.36 mm., thickness of single valve 0.16 mm.

Cytherella kansasensis is distinctive in its nearly perfect elliptical outline in side view. Jones and Hinde (**10**) figure a specimen which they refer to as an oval variety of *C. ovata* (Roemer) which is nearly as symmetrical as our species. *C. marlboroensis* Ulrich (**17**, pp. 117–118, pl. 16, figs. 9–13) from the Maryland Eocene is similar in outline though its height is two-thirds the length, contrasted to one-half in *C. kansasensis*.

From the basal Niobrara. This species is very rare and has been found only at the locality given below.

Holotype from sec. 31, T. 12 S., R. 22 W., Ellis County, Kansas. U. S. National Museum, No. 75398.

CYTHERELLA ? UNILACUNA Morrow, n. sp.
Plate 31, figures 12*a–b*, 13*a–b*

Carapace elongate-oval in side view, greatest height near the anterior end; posterior and anterior ends evenly rounded; dorsal and ventral edges converging slightly posteriorly, straight or slightly convex; in dorsal view carapace moderately convex, greatest thickness posterior to the middle, evenly rounded; no hinge structure apparent; surface smooth, with a shallow subcircular pit dorsal and slightly posterior to the center; posterior and anterior end with a narrow marginal rim. Length 0.4 mm., height 0.24 mm., thickness of left valve 0.12 mm.

Only a few specimens of single valves of this species have been found. The most characteristic feature of the carapace is the shallow pit.

The reference of this species to *Cytherella* is unsatisfactory but until both valves can be found its generic assignment must remain doubtful. It seems likely that *Cytherella unilacuna*, n. sp., *C. submarginata* Ulrich (**17**, p. 118, pl. 16, figs. 14, 15), an Eocene species, and possibly a form figured by Bonnema (**36**, p. 290) as *C. ? n. sp.* belong to a distinct genus, characterized by a well-defined pit a little dorsal to the center, a narrow thickened rim at each end, and a smooth surface. Ulrich's holotype is two and one-half times as long as *C. unilacuna*, is relatively a little more elongate with the dorsal and ventral sides more nearly parallel.

Only a few specimens of single valves have been found and they are all from the Hartland shale member.

Holotype from sec. 31, T. 21 S., R. 22 W., Hodgeman County, Kansas. U. S. National Museum, No. 75399.

Genus CYTHERELLOIDEA Alexander, 1929

CYTHERELLOIDEA sp.
Plate 31, figures 7*a–b*

Carapace oblong and subquadrangular in side view; valves flat with very shallow internal cavity, greatest thickness near the posterior end; dorsal and ventral margins straight, parallel; posterior and anterior ends rounded, anterior end more sharply than ventral; periphery thick-

ened; two horizontal ridges originating anterior to the middle are joined near the posterior end by a thickened U-shaped ridge, a third horizontal ridge lies near the ventral edge and parallels it; surface granular. Length 0.58 mm., height 0.34 mm., thickness of left valve, 0.2 mm.

A single specimen from the Hartland shale, associated with *Cytherella ? unilacuna* represents this species. It is readily distinguished from the species of this genus figured by Alexander in the arrangement of the horizontal ridges and in having the dorsal and ventral edges more nearly parallel.

Family CYPRIDAE

Genus CYTHEREIS Jones, 1849

CYTHEREIS ALEXANDERI Morrow, n. sp.

Plate 31, figures 14 *a–c*

Carapace elongate-ovate in side view; dorsal and ventral margins straight and nearly parallel, height one-half the length, greatest height near the anterior end which is broadly rounded; posterior end compressed, produced and angled a little above the middle, denticulate below; surface ornamented by a prominent, long, sharp ventral ridge which terminates posteriorly in a long spine that is directed slightly backward and by a shorter and weaker dorsal ridge bearing a low spine directly above the ventral spine, a short horizontal ridge lies midway between these spines, and anterior to it is an elongate or rounded elevation; surface covered with coarse, mesh-like reticulations; hinge on right valve has a short, heavy tooth at each end. Length of holotype 0.7 mm., height 0.35 mm., thickness of single valve excluding spine 0.18 mm., with spine 0.28 mm.

This species is easily distinguished from the others associated with it by the elongate outline with subparallel dorsal and ventral margins, the strong ventral ridge and spine, and the coarse reticulations on the surface. Only a few specimens have been found but they show very little variation. It does not closely resemble any described species known to the writer.

Rare in the basal Niobrara.

Holotype from sec. 32, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75400.

CYTHEREIS ALEXANDERI ABBREVIATA Morrow, n. var.

Plate 31, figures 8*a–c*

Carpace elongate-ovate; ventral margin slightly convex, dorsal margin nearly straight, curved a little upward anteriorly, posterior end compressed, produced, rounded and denticulate below, anterior end evenly rounded, curving a little below the ventral margin and slightly above the dorsal margin; surface ornamented by a ventral and dorsal ridge, each terminated posteriorly by a blunt spine, the ventral spine being the longer; a short horizontal ridge lies midway between the spines and a prominent rounded elevation lies in front of the ridge, anterior to the center. Length of holotype 0.6 mm., height 0.3 mm.

It is consistently smaller than *C. alexanderi*, tapers posteriorly, and its ornamentation, though similar, is more subdued.

This variety is quite common locally in the basal Niobrara samples.

Holotype from sec. 31, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75401.

CYTHEREIS NIOBRARENSIS Morrow, n. sp.

Plate 31, figures 6, 10*a–c*

Carapace elongate subovate in side view, ventral margin straight, dorsal margin slightly concave, curving upward to meet the broadly rounded anterior edge in a subangular junction, posterior end more sharply rounded below but curving sharply upward joining the dorsal edge at about 90°, carapace highest near anterior end; anterior end thickened to form a distinct rim, denticulated at the margin; posterior end abruptly compressed, denticulated below; sides of carapace ornamented by a short median, prominent, horizontal posterior ridge,

and in front of it, just anterior to the center, a low rounded elevation, a second ventral ridge rising near the anterior end terminates in a prominent, sharp node; surface reticulated; valves subequal. Length 0.6 mm., height 0.34 mm., breadth 0.36 mm.

Of the American Cretaceous species, it appears to be most like *Cythereis dentonensis* Alexander (**30,** p. 94, pl. 8, figs. 10, 11) from the Comanchean of Texas. The median, horizontal ridge of the Kansas species is replaced in *C. dentonensis* by an obscure central node, the outline of the posterior end of the two species is quite different. The large number of specimens examined indicates that this species is quite constant in its characters.

C. niobrarensis is the most common ostracode species found in this study, though it is restricted to the basal Niobrara.

Holotype from sec. 31, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75402.

CYTHEREIS SUBGRACILIS Morrow, n. sp.

Plate 31, figures 9*a–c*

Carapace in side view elongate, subovate, ventral margin straight, dorsal margin nearly straight, curving upward in front, ventral and dorsal margins converging slightly behind; anterior margin evenly curved, making a subangular junction with the dorsal margin; posterior end abruptly and strongly compressed. A low, median, horizontal ridge, strongest back of the middle, runs forward and joins a prominent, broad, rounded knob anterior to the center. Anterior end thickened into a broad rim; posterior margin thickened, denticulate along the posterior ventral edge. In edge view the greatest thickness is about midway between the posterior end and the middle. Ventral edge very broad, almost flat, joining the lateral sides rather abruptly; surface finely reticulated; valves subequal. Length of holotype 0.6 mm., height at posterior end 0.3 mm., at anterior end 0.2 mm., greatest breadth 0.3 mm.

Though this species is closely related to *Cythereis niobrarensis* it differs considerably in detail It lacks the denticulate anterior edge, is relatively more elongate and broader, and lacks the posterior ventral spine.

This species has been found only at the basal Niobrara locality given below where it is very rare.

Holotype from sec. 31, T. 11 S., R. 16 W., Ellis County, Kansas. U. S. National Museum, No. 75403.

REFERENCES

(1) d'Orbigny, A.D., *Ann. Sci. Nat.*, vol. 7, 1826.
(2) Nillson, *Petref. Suec.*, 1828.
(3) d'Orbigny, A.D., *Voy. Amer. Merid.*, vol. 5, pt. 5, 1839.
(4) d'Orbigny, A.D., *Mem. Soc. Geol. France*, ser. 1, vol. 4, 1840.
(5) Bailey, J. W., *Am. Jour. Sci. and Arts*, vol. 41, 1841.
(6) Ehrenberg, C. G., Memoir on the extent and influence of microscopic life in South and North America, 1843.
(7) Ehrenberg, C. G., *Mikrogeologie*, pt 1, 1854.
(8) Reuss, A. E., *Sitz. Akad. Wiss. Wien*, vol. 40, 1860.
(9) Reuss, A. E., Die Foraminiferen des norddeutschen Hils und Gault, Bde. 46, *Sitzung. d. Kais. der Wissenschaften*, 1863.
(10) Jones and Hinde, Supplementary monograph of the Cretaceous Entomostroca of England and Ireland: *Paleontogr. Soc. London*, 1889.
(11) Williston, S. W., *Kansas Acad. Sci., Proc.*, 1890.
(12) Woodward Anthony, and Thomas, B. W., Microscopic fauna of the Cretaceous of Minnesota with additions from Nebraska and Illinois: *Minnesota Geol. and Nat. Hist. Survey*, 1893.
(13) Calvin, S., *Iowa Geol. Survey*, vol. 3, 1893.
(14) Calvin, S., *Am. Geologist*, Sept., 1894.
(15) Schako, *Arch. Ver. Freunde Nat. Mecklenburg*, vol. 50, 1896.
(16) McClung, C. E., Microscopic organisms of the Upper Cretaceous: *Kansas Univ. Geol. Survey*, vol. 4, 1898.
(17) Ulrich, E. O., *Maryland Geol. Survey*, Eocene, 1901.
(18) Berry, W., The Upper Cretaceous Ostracoda from Maryland: *Am. Jour. Sci.*, 5th ser., vol. 9, 1925.

(19) Franke, *Abhandl. Geol. Pal. Instit. Univ. Greifswald*, vol. 6, 1925.
(20) Plummer, H. J., *Texas Univ., Bull.* 2644, 1926.
(21) Carsey, D. O., *Texas Univ., Bull.* 2612, 1926.
(22) Cushman, J. A., *Contr. Cushman Lab. Foram. Research*, vol. 2, pt. 1, 1926.
(23) Moreman, W. L., Fossil zones of the Eagle Ford of North Texas: *Jour. Paleontology*, vol. 1, 1927.
(24) Alexander, C. I., *Jour. Paleontology*, vol. 1, no. 1, 1927.
(25) Cushman, J. A., *Jour. Paleontology*, vol. 1, no. 3, 1927.
(26) Vanderpool, H. C., *Jour. Paleontology*, vol. 2, no. 2, 1928.
(27) Nuttall, W. L. F., *Jour. Paleontology*, vol. 2, no. 4, 1928.
(28) Carman, K., *Jour. Paleontology*, vol. 3, no. 3, 1929.
(29) Cushman, J. A., *Contr. Cushman Lab. Foram. Research*, vol. 5, pt. 4, 1929.
(30) Alexander, C. I., Ostracodes of the Cretaceous of North Texas: *Texas Univ., Bull.* 2907, 1929.
(31) Israelsky, M. C., *Arkansas Geol. Survey, Bull.* 2, 1929.
(32) Cushman, J. A., and Wickenden, R. T. D., *Contr. Cushman Lab. Foram. Research*, vol. 6, pt. 2, 1930.
(33) Cushman, J. A., Foraminifera of Tennessee: *Division of Geology, Bull.* 41, 1931.
(34) Cushman, J. A., *Contr. Cushman Lab. Foram. Research*, vol. 7, pt. 4, 1931.
(35) Cushman, J. A., and Ponton, Gerald M., *Contr. Cushman Lab. Foram. Research*, vol. 8, pt. 3, 1932.
(36) Bonnema, J. H., *Jour. Paleontology*, vol. 6, no. 3,1932.
(37) Sandidge, J. R., *Jour. Paleontology*, vol. 6, no. 3, 1933.
(38) Vanderpool, H. C., Upper Trinity microfossils from southern Oklahoma: *Jour Paleontology*, vol. 7, no. 4, 1933.

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OSTRACODA OF THE MIDWAY (EOCENE) OF TEXAS

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ABSTRACT

Thirty-eight species of Ostracoda (thirty-one new), belonging to fifteen genera and four families, are described. The relationships of Midway species to species in the underlying Cretaceous and in the overlying Tertiary formations are discussed. Complete generic descriptions, including the relationships of the inner and outer margins of the shell and the line of concrescence, and the number and character of the radial pore-canals, are provided for each of the genera recognized. One genus previously known only from the Recent seas, and three genera which have not been recorded from strata earlier than the Oligocene are recognized in the Midway fauna of Texas.

In 1926, Mrs. Helen Jeanne Plummer published her monograph on the Foraminifera of the Midway formation of Texas,[1] and three years later, the writer published a paper on the Ostracoda of the Cretaceous of Texas.[2] Shortly after the publication of the latter paper, Mrs. Plummer suggested that a cooperative study be made of the Midway Ostracoda, and generously offered to supply the specimens from her extensive collections from the Midway strata in Texas.

This study was begun and continued intermittently for three years. Recently, however, Mrs. Plummer has informed the writer that other duties made it impossible for her to continue her work on the investigation, and urged that the study be completed without further delay. The manuscript was assembled and presented to her for approval. She examined it carefully and made numerous helpful suggestions, but insisted that she did not feel justified in accepting co-authorship.

The writer regrets that it is necessary, therefore, to publish this paper under his name alone, instead of under both names, as originally planned, and wishes to express his gratitude to Mrs. Plummer, whose unfailing generosity and interest have made this investigation possible.

During the summer of 1933, a grant-in-aid from the National Research Council enabled the writer to enlarge his own collections from the Midway formation, and to secure extensive collections from the other Tertiary formations of Texas and Louisiana. These collections have afforded the opportunity of making numerous observations concerning the relationships of various species in the Midway to species in the overlying Tertiary formations.

[1] Plummer, Helen Jeanne, Foraminifera of the Midway formation in Texas: *Texas Univ., Bull.* 2644, 1926.

[2] Alexander, C. I., Ostracoda of the Cretaceous of North Texas: *Texas Univ., Bull.* 2907, 1929.

The Midway ostracode fauna has proved to be one of exceptional interest. Four species which have been recorded from the underlying Navarro formation, *Cytherella tuberculifera* Alexander, *Bairdia magna* Alexander, *Cytheridea everetti* Berry and *C. fabaformis* (Berry), occur also in the Midway. Other Midway species differ but little from ancestral forms occurring in the underlying Cretaceous formations. Descendants of many Midway species can be recognized, in turn, in the overlying Tertiary formations.

The genus *Cytheromorpha*, represented in the Midway fauna by a single species, has been previously known only in the Recent seas. Three other genera, *Argilloecia*, represented in the Midway fauna by two species, and *Eucythere* and *Xestoleberis*, each represented by one species, have not been previously recorded from strata older than Oligocene. Delo has assigned a species from the Pennsylvanian of Texas to the genus *Argilloecia*,[3] but this allocation is apparently erroneous. His species appears to be a *Bythocypris*, as the left valve is larger than, and overlaps, the right, while in all known fossil and Recent species of the genus *Argilloecia*, the right valve is the larger.

In a recent paper on the genus *Cytheropteron*[4] the writer discussed the importance of the finer details of shell structure in the correct generic allocation of fossil ostracodes, and demonstrated that numerous erroneous assignments of fossil species had resulted from the failure of paleontologists to observe these features. Complete generic descriptions of all the genera recognized in the Midway fauna, including not only the general shape of the shell, the relative size of the two valves, the general type of surface sculpture, and the hinge structure, but also the relationships of the inner and outer margins of the shell and the line of concrescence, and the number and character of the radial pore-canals, are provided in this paper. The figures illustrating these structures are drawn, in some cases, from actual specimens of the type species of the genus in question, in other cases from previous figures of the genotype, and in still others from species in the Midway fauna, after these species had been compared in detail with descriptions and figures of the type species of the genus to which they are referred.

Thirty-eight species, belonging to fifteen genera and four families, were recognized in the Midway ostracode fauna. Eleven species, *Cytherella turgidula*, n.sp., *C. tuberculifera* Alexander, *Argilloecia subcylindrica*, n.sp., *Brachycythere foraminosa*, n.sp., *Cytheridea everetti* Berry, *C. fabaformis* (Berry), *C. ruida*, n.sp., *C. fornicata*, n.sp., *Loxoconcha nuda*, n. sp., *L. prava*, n.sp., and *Cytheropteron aligerum*, n.sp., have been recorded in the writer's collections from the lower Midway strata only. Seven species, *Cytherella symmetrica*, n.sp.,

[3] Delo, D. M., Some Upper Carboniferous Ostracoda from the shale basin of western Texas: *Jour. Paleontology*, vol. 4, p. 174, pl. 13, fig. 11, 1930.

[4] Alexander, C. I., Shell structure of the Ostracode genus *Cytheropteron*, and species from the Cretaceous of Texas: *Jour. Paleontology*, vol. 7, pp. 181–214, 1933.

Bairdia suborbiculata, n.sp., *Brachycythere formosa*, n.sp., *Loxoconcha corrugata*, n.sp., *Cytheropteron midwayensis*, n.sp., *Monoceratina rossae*, n.sp., and *M. speciosa*, n.sp., appear to be confined to the upper Midway. Most of these species are too rare to be of any practical value in differentiating the upper and lower Midway strata, however, and several are known from the type locality only. *Brachycythere formosa* n.sp., which has been observed only in the upper Midway, as indicated above, is the only species sufficiently abundant to be of value in distinguishing the upper and lower Midway beds.

The Midway "formation" of earlier writers has recently been raised to the rank of group, and formation names have been applied to the upper and lower divisions. Dr. Julia Gardner has proposed the name Kincaid formation for the lower Midway of earlier writers,[5] and this name has been accepted by the United States Geological Survey and the Texas State Bureau of Economic Geology. F. B. Plummer has divided the Kincaid into (1) the Littig glauconite member, a bed of glauconite and sand ranging from 8 inches to 15 feet thick at the base of the formation, and (2) the Pisgah member, which includes the overlying clays, glauconitic clays, glauconitic sands and limestone lentils.[6] The name Wills Point, applied by Penrose[7] to the Midway of Texas, and later rejected as a synonym for the earlier name, has been restricted and applied to the upper division of the Midway only.[8] Wills Point, as now defined, includes all the strata below the Wilcox sand, and above the Tehuacana limestone lentil of the Kincaid formation, or its equivalent horizon. The upper Midway clays crop out in the vicinity of Wills Point, Van Zandt County, Texas. The Wills Point formation has been divided into (1) the Mexia clay member, consisting of dark, thinly laminated or compact, fossiliferous clays, with a thin, glauconitic sand layer at its base (*Vernericardia bulla* zone), (2) the Wortham aragonite lentil, a concretionary, persistent stratum of limestone 8 to 10 inches thick, having a crystalline structure in which many of the crystals of aragonite are arranged in the form of rosettes, and (3) the Kerens clay member, consisting of dark-gray, silty or sandy clay.[9]

The localities from which the samples used in this investigation were collected will be described in a separate section at the end of the paper. All references to localities in the text will be made by number. The position of the various samples in the Midway section is shown in the accompanying generalized geologic column.

The holotype or cotypes of all new

[5] Gardner, Julia, Kincaid formation, name proposed for lower Midway of Texas: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 17, p. 744, 1933.

[6] Plummer, F. B., The geology of Texas—Cenozoic systems: *Texas Univ., Bull.* 3232, p. 536, 1933.

[7] Penrose, R. A. F., A preliminary report on the geology of the Gulf Tertiary of Texas, from Red River to the Rio Grande: *Texas Geol. Survey, Ann. Rept.*, 1, p. 19, 1889.

[8] Plummer, F. B., *Op. cit.*, p. 555.

[9] Plummer, F. B., *Op. cit.*, p. 559.

species, and the plesiotypes of all other species described in this paper will remain in the writer's personal micropaleontological collections.

All illustrations were drawn by the author.

DESCRIPTION OF GENERA AND SPECIES

Order OSTRACODA Latreille

Suborder PLATYCOPA Sars

Family CYTHERELLIDAE Sars, 1865

Genus CYTHERELLA Jones, 1849

The carapace in the genus *Cytherella* is elongate, elliptical, roundly quadrangular, or reniform in side view, and is more or less compressed, especially anteriorly. The shell wall is thick and heavy and the surface either smooth or finely punctate. The right valve is conspicuously larger than the left, and overlaps it around the entire periphery. The edge of the smaller, or left, valve fits into a distinct groove just within the outer margin of the right valve. There are no hinge teeth.

The muscle-scar area lies slightly above and in front of the center of the valves. It is oval or elliptical, and its long axis is almost at right angles to that of the shell, the upper end of the axis being slightly nearer the anterior end of the shell than the lower end. The muscle-scar area in most species is marked by a slight elevation on the interior of the valves, and in some species by a slight depression on the exterior. Along each side of the longitudinal axis is a row of narrow muscle scars (Pl. 32, figs. 4, 5). This muscle-scar pattern is characteristic not only of the genus *Cytherella*, but of all genera of the family Cytherellidae.

There is no marginal zone with pore-canals in the carapace of Cytherellidae. The inner lamella is entirely membranous.

Members of the genus *Cytherella* are marked by pronounced sexual dimorphism. The shell of the female is distinctly higher and broader than that of the male, especially at the posterior end.

Genotype, *Cytherina ovata* Roemer.

CYTHERELLA TUMIDOSA Alexander, n.sp.
Plate 32, figures 1, 2, 5, 6; Plate 35, figures 3, 4

Female carapace ovate in side view, highest slightly behind the middle. Dorsal margin strongly arched, curving downward somewhat more abruptly toward the posterior than toward the anterior end. Ventral margin distinctly and evenly convex downward. Anterior end broadly and evenly rounded. Posterior end broadly rounded, slightly oblique. Right valve overlapping the left somewhat more strongly along the anterior half of the dorsal and the middle of the ventral margins than elsewhere, and very slightly along the lower half of the posterior margin. Carapace in dorsal view elongate ovate, widest slightly behind the middle, sides of carapace sloping flatly toward each end from the point of greatest width; anterior end subacute, posterior roundly truncated, obtuse. Surface of valves smooth.

Male carapace oblong ovate in side view, highest at middle. Dorsal margin gently arched, sloping more steeply toward the posterior than toward the anterior end. Anterior end broadly and evenly rounded. Posterior end low, narrower than anterior, and obliquely rounded. Right valve overlaps left as in female. In dorsal view, carapace widest slightly behind middle, sides of carapace sloping flatly toward each end; ends similar, subacute.

Measurements of cotypes: female, length 1.0 mm., height 0.66 mm., width 0.5 mm; male, length 0.88 mm., height 0.55 mm., width 0.4 mm.

The female of this species resembles that of *C. complanata* (Reuss)[10] but is

[10] This species, originally described by Reuss in his "Versteinerungen der böhmischen Kreideformation," (p. 16, pl. 5, fig. 35, 1845), was so poorly figured that the actual characters of the species have not been known. The

readily distinguished (1) by the greater ratio of height to length of carapace, (2) the position of greatest height distinctly behind rather than at the middle, (3) the slightly curved, rather than flat, anterior slope of the dorsal margin in front of the highest point, and (4) the less strongly inflated and blunt outline of the shell in dorsal view.

The male of *C. tumidosa* is similar to that of *C. ovata* (Roemer) and of *C. complanata* (Reuss), but it differs from both in the greater height of the shell and in the less strongly narrowed posterior end. It differs also from *C. ovata* in that (1) the dorsal and ventral margins converge less strongly anteriorly, (2) the overlap of the right valve upon the left is but slightly greater along the anterior half of the dorsal margin than along the posterior half, and (3) the ventral overlap is greatest at the middle rather than along the anterior half of the margin; and from *C. complanata* in that in dorsal view the surface of the valves slopes flatly toward each end instead of being gently convex.

C. tumidosa is common in the Wills Point formation and appears rarely in outcrops of the Kincaid.

Type locality, station 21.

writer has recently examined specimens of the species from the type locality at Luschitz, Bohemia, identified by Reuss himself, and now deposited in the Paleontology Museum of Harvard University. The species described by Alexander under the name *Cytherella obesa* (Ostracoda of the Cretaceous of North Texas: *Texas Univ., Bull.*, 2907, p. 51, pl. 1, figs. 3, 6, 1929) proves to be identical with Reuss' *C. complanata*.

CYTHERELLA TURGIDULA Alexander, n.sp.
Plate 32, figures 7, 8; Plate 35, figures 1, 2

Female carapace ovate in side view, highest about at middle. Dorsal margin arched, with flat anterior and with slightly steeper and more curved posterior slope. Ventral margin gently and evenly convex downward. Anterior end broadly and evenly rounded. Posterior end slightly narrowed, obliquely rounded, with right valve projecting strongly beyond the left and bluntly angled slightly below the middle. Right valve overlaps left but slightly along upper and lower portions of the posterior border, and moderately around remainder of periphery. Carapace in dorsal view widest slightly behind middle; anterior end subacute, posterior roundly obtuse. Surface of valves smooth.

Carapace of male oblong ovate, highest at middle. Dorsal margin arched, with posterior slope slightly steeper than anterior. Ventral margin nearly straight, very slightly convex downward. Anterior end broadly rounded. Posterior end somewhat narrowed, low, obliquely rounded.

EXPLANATION OF PLATE 32

FIGS. 1, 2, 5, 6—*Cytherella tumidosa* Alexander, n. sp.; 1, female, left valve view; 2, male, left valve view; 5, interior of right valve of male; 6, interior of left valve of male. (p. 209)

3, 4—*Cytherella excavata* Alexander, n. sp.; 3, male, left valve view; 4, female, left valve view. (p. 211)

7, 8—*Cytherella turgidula* Alexander, n. sp.; 7, female, left valve view; 8, male, left valve view. (p. 210)

9—*Cytherella symmetrica* Alexander, n. sp., female, left valve view. (p. 212)

10—*Cythereis cancellosa* Alexander, n. sp.; right valve view. (p. 221)

11—*Cythereis spiniferrima* Jones and Sherborn; right valve view. (p. 220)

12—*Bairdia suborbiculata* Alexander, n. sp.; right valve view. (p. 215)

13—*Cythereis sculptilis* Alexander, n. sp.; right valve view. (p. 221)

14, 15—*Cythereis prestwichiana* Jones and Sherborn; 14, right valve view; 15, detail of surface ornamentation, ×160. (p. 220)

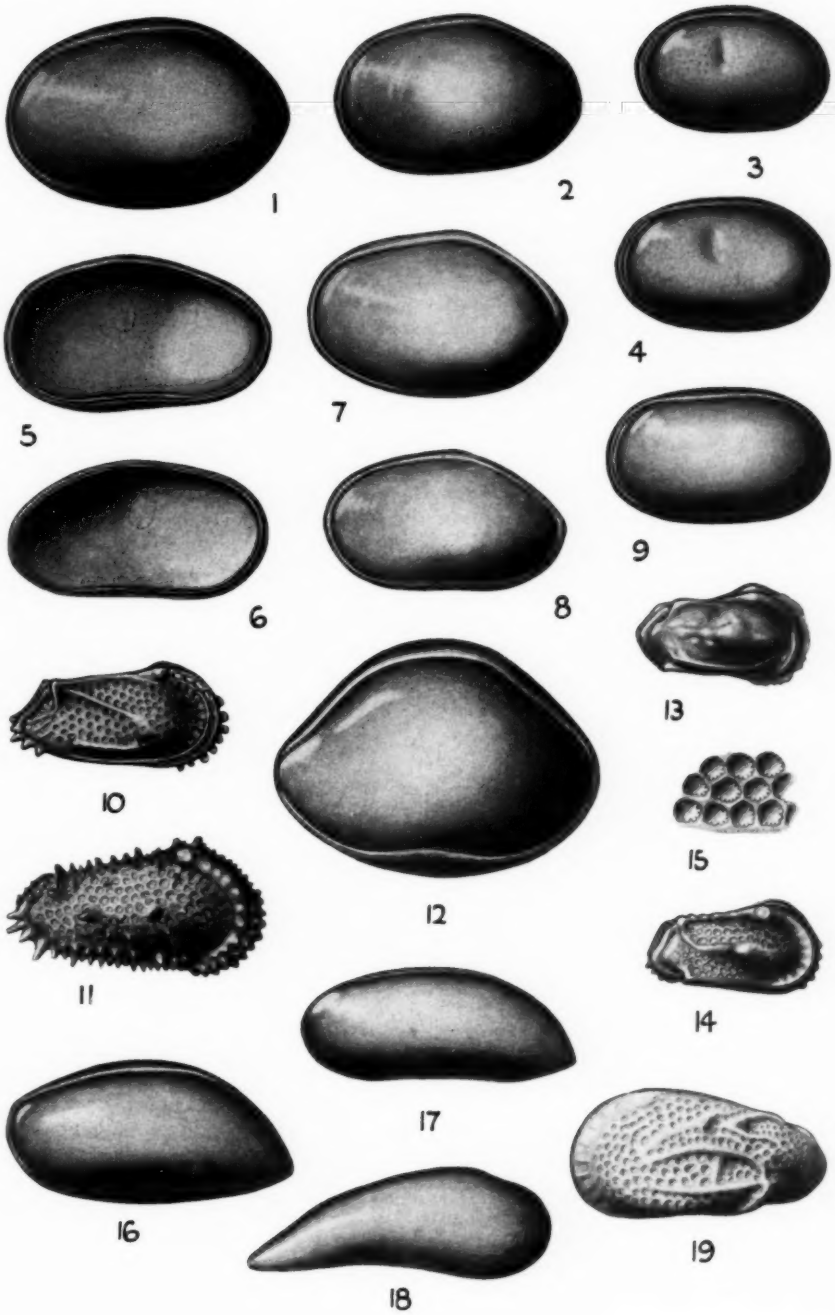
16—*Argilloecia faba* Alexander, n. sp.; left valve view, ×95. (p. 213)

17—*Argilloecia subcylindrica* Alexander, n. sp.; left valve view, ×95. (p. 214)

18—*Paracypris perapiculata* Alexander, n. sp.; right valve view. (p. 214)

19—*Cytheromorpha scrobiculata* Alexander, n. sp.; lateral view, left valve, ×80.

All figures ×40, unless otherwise indicated. (p. 223)



Alexander, Eocene ostracodes

Right valve overlaps left as in female, but overlap is less pronounced. Carapace in dorsal view widest slightly behind middle, surfaces of valves sloping flatly toward each end; ends similar, subacute.

Measurements of cotypes: female, length 0.9 mm., height 0.6 mm., width 0.43 mm.; male, length 0.85 mm., height 0.5 mm., width 0.33 mm.

The female of this species is somewhat similar to that of *C. tuberculifera* Alexander, from the Navarro formation, but is distinguished by (1) the markedly greater ratio of height to length of carapace, (2) the obliquely instead of evenly rounded posterior end, and (3) the position of greatest width slightly behind the middle rather than at the posterior end. The male of *C. tuberculifera* is unknown.

The male of *C. turgidula* is very similar to that of *C. complanata* (Reuss). It differs, however, (1) in the more strongly arched dorsal margin, (2) the narrower and more obliquely rounded posterior end, (3) the slight but distinct projection of the right valve near the middle of the posterior margin, and (4) the flat slope of the valve surfaces toward anterior and posterior ends, in dorsal view.

The male of *C. turgidula* is even more similar in outline to that of *C. ovata* (Roemer). The right valve of *C. ovata* overlaps the left strongly along the anterior portion of the dorsal margin, and but slightly less along the anterior portion of the ventral margin, whereas in *C. turgidula* the overlap is moderate and nearly uniform around the entire periphery, with the exception of the strong projection at the posterior end.

C. turgidula has been observed only in the Kincaid formation.

Type locality, station 3.

CYTHERELLA EXCAVATA Alexander, n. sp.

Plate 32, figures 3, 4; Plate 35, figures 5, 6

Cytherella beyrichi JONES, *1856*, (non *C. beyrichi* Reuss, 1851), Mon. Tert. Entom. England, Paleont. Soc. London, p. 55, pl. 5, fig. 12.

Female carapace oblong ovate in side view, highest slightly behind middle. Dorsal margin very gently arched. Ventral margin slightly and evenly convex downward. Anterior end broadly and evenly rounded. Posterior end broadly rounded, slightly oblique. Right valve overlaps left moderately and almost uniformly around entire periphery; overlap slightly less around anterior end and in lower half of posterior margin than elsewhere. Surface of valves coarsely and discretely punctate, and bearing a shallow, but distinct oval pit that corresponds in position and shape to the muscle-scar area on the interior of the valves. Anterior border of left valve bears a narrow marginal ridge or flange. Carapace in dorsal view widest near posterior end; anterior end subacute, posterior roundly truncated; sides of valves gently convex.

Male carapace similar in outline to that of female, but with posterior end slightly lower and more oblique, and more strongly compressed.

Measurements of cotypes: female, length 0.75 mm., height 0.45 mm., width 0.34 mm; male, length 0.67 mm., height 0.45 mm., width 0.3 mm.

C. excavata is similar in general appearance and in surface ornamentation to *C. beyrichi* (Reuss) from the Oligocene, Septarian clays, of Germany.[11] The writer has procured, through exchange with Dr. A. Franke of Arnstadt, Germany, a sample of these "septarian clays" from the vicinity of Berlin, as well as Oligocene clays from other localities in Germany. Specimens of *C. beyrichi* have been found in these samples. The carapace of this species is widest and is squarely truncated at the posterior end; in dorsal view the anterior end is blunt, and the sides of the valves flat, or even slightly concave. In lateral view the dorsal margin is arched, but the ventral margin is straight or slightly concave. *C. beyrichi* is also much larger than *C. excavata*.

[11] Reuss, A. E., Ueber die fossilen Foraminiferen und Ostracoden der Septarienthone der Umgegend von Berlin: *Zeits. deutsch. geol. Gesell.*, vol. 3, p. 89, pl. 17, fig. 65, 1851.

Several similar but distinct species have been recorded by various authors under the name *C. beyrichi*. Reuss' original figures of the species are very poor, and give a very erroneous conception of the specific characters. Speyer[12] has published the best figures of the true *C. beyrichi*. His specimens were collected from the Oligocene clays in the vicinity of Cassel, in northern Germany. The species described and figured by the same writer under the name *C. transversa*[13] is undoubtedly the male of the same species.

Jones and Sherborn[14] described three species of the "*C. beyrichi* group" as occurring in the London clay (Eocene) of England. The three species are *C. fabacea* (Bornemann), *C. beyrichi* (Reuss), and *C. compressa* (Münster). It is doubtful whether any of the three forms from the London clay belong to the species to which Jones and Sherborn assigned them. All three species were originally described from strata of Oligocene age in Germany. Lienenklaus[15] has expressed the belief that the form described by Bornemann under the name *C. fabacea* is an immature male of *C. compressa*, and the present writer agrees with this interpretation. The form referred by Jones and Sherborn to *C. compressa* (Münster) was originally described by Jones[16] under the name *C. londinensis*, and this name may, therefore, be regarded as a valid name for the species, rather than as a synonym for *C. compressa* (Münster). The form referred to *C. beyrichi* by the same authors appears to be very close to *C. excavata*, n. sp.

C. excavata has been found in both the Kincaid and Wills Point formations, but at most localities is rather rare.

Type locality, station 21.

CYTHERELLA SYMMETRICA Alexander, n. sp.
Plate 32, figure 9; Plate 35, figure 13

Female carapace elongate-quadrate in outline. Dorsal and ventral margins nearly straight and parallel, slightly and evenly convex. Anterior end broadly and evenly rounded. Right valve overlaps left moderately around entire periphery; overlap slightly less around anterior end and in lower half of posterior margin than elsewhere. Anterior border of left valve bears a very fine, narrow, obscure marginal rim or flange. Surface of valves smooth or finely and densely punctate. Valves moderately convex. In dorsal view carapace widest at, or slightly behind, middle; anterior end subacute, posterior end blunt, rounded.

The male of this species has not been recognized.

Measurements of holotype: length 0.79 mm., height 0.46 mm., width 0.36 mm.

C. symmetrica is similar in form and in surface marking to *C. münsteri* (Roemer). The carapace of the latter species, however, is widest at the posterior end, and in dorsal view the posterior end is squarely truncated, with the valve surfaces sloping flatly toward the anterior end.

C. symmetrica has been found as a rare form in some outcrops of the Wills Point formation.

Type locality, station 21.

CYTHERELLA TUBERCULIFERA Alexander
Cytherella tuberculifera ALEXANDER, *1929*, Texas Univ., Bull. 2907, p. 52, pl. 2, fig. 3.

This distinctive species, which occurs in the Navarro clays of Texas, has also been observed as an occasional member of the microfauna of the Kincaid formation.

[12] Speyer, O., Die Ostracoden der Casseler Tertiärbildungen, p. 54, pl. 1, fig. 1, 1863.

[13] Speyer, O., *Op. cit.*, p. 56, pl. 1, fig. 2.

[14] Jones, T. R., and Sherborn, C. D., Further notes on the Tertiary Entomostraca of England, with special reference to those of the London clay: *Geol. Mag.*, n. ser., dec. 3, vol. 4, p. 458, 1887.

[15] Lienenklaus, E., Monographie der Ostracoden des nordwestdeutschlands Tertiärs: *Zeits. deutsch. geol. Gesell.*, vol. 46, p. 116, 1894.

[16] Jones, T. R., Monograph of the Tertiary Entomostraca of England: *Paleont. Soc. London*, p. 55, pl. 5, fig. 20, 1856.

Suborder PODOCOPA Sars

Family CYPRIDAE Baird, 1846

Genus ARGILLOECIA Sars, 1865

The carapace of this generic group is small, thin and fragile. In side view it is long, narrow and siliquose. The anterior end is rounded; the posterior tapers to an acute or subacute point. The dorsal margin is more or less strongly convex, the ventral margin straight or slightly sinuate. The right valve, as in *Macrocypris*, is larger than the left, and overlaps it both dorsally and ventrally. The surface of the carapace is smooth.

The hinge structure, as in all members of this family, is simple, the dorsal edge of the smaller valve fitting into a slight groove in the hinge-margin of the larger.

The marginal zone is broad, and the pore-canals long, very numerous, and closely spaced, especially at the anterior end. The canals are nearly straight, except in the antero-ventral region, where they curve strongly backward. Nearly all are simple, although a few appear to bifurcate near the outer margin of the shell (Pl. 35, fig. 14).

The shell is so thin and fragile that no fossil valves have been found in which the calcified portion of the inner lamella of the shell is completely preserved. In one specimen in the writer's collections, the inner lamella is nearly complete at the anterior end, and the inner margin is seen to be approximately one-fourth the length of the carapace from the outer margin of the shell.

The longitudinal axis of the roughly-oval muscle-scar area, located near the middle of the valve, is nearly parallel to that of the shell. The muscle-scars vary in number in different species. The usual number appears to be five although a few species have only four. The Midway species have five muscle scars. Three long, narrow scars in the anterior part of the area are longitudinally disposed, and nearly parallel, but converge somewhat anteriorly; behind these are two scars, the upper one with its long axis directed obliquely downward and backward, the lower one somewhat irregular in shape. (Pl. 35, fig. 14.)

The species of *Argilloecia* herein described are the earliest known, certainly identified representatives of the genus. The only other recorded occurrence of a member of this genus in strata of Tertiary age is a tentative reference of some specimens from the Oligocene of Germany to the Recent species *A. acuminata* G. W. Müller, by Lienenklaus.[17] The specific identification may be questioned, but the generic allocation appears to be correct. The writer has already referred to Roth's apparently erroneous assignment of a species from the Pennsylvanian of Texas to the genus *Argilloecia*.

ARGILLOECIA FABA Alexander, n. sp.

Plate 32, figure 16; Plate 35, figures 12, 14

Carapace minute, in side view elongate, highest slightly behind middle. Height equal to nearly one-half of length. Dorsal margin rather strongly arched, curving downward somewhat more steeply posteriorly than anteriorly from highest point of arch. Ventral margin nearly straight, very slightly convex downward. Anterior end low, obliquely rounded. Posterior end tapering to rather blunt postero-ventral angle. Right valve overlaps left distinctly both dorsally and ventrally, with strongest overlap along anterior half of dorsal margin and at middle of ventral margin. Carapace in side view lanceolate, widest at middle; ends similar, acute. Surface of valves smooth.

Length of holotype, 0.42 mm., height 0.2 mm., width 0.16 mm.

A. faba has been found as a very rare member of the microfauna of both the Kincaid and Wills Point formations. A similar species occurs in the Taylor formation of the Upper Cretaceous of Texas, but is distinguished by pronounced differences in the shape of the carapace.

Type locality, station 21.

[17] Lienenklaus, E., Die Ostracoden der Mainzer Tertiärbeckens: *Berich. d. Senckber. Natur. Gesell.*, p. 17, 1905.

ARGILLOECIA SUBCYLINDRICA Alexander, n. sp.
Plate 32, figure 17; Plate 35, figure 16

Carapace in side view, narrow, elongate, height equal to about one-third of length; highest anterior to middle. Dorsal margin gently arched. Ventral margin nearly straight, slightly concave at middle. Anterior end obliquely rounded. Posterior end tapering to subacute postero-ventral angle. Right valve but slightly larger than left; overlap distinct only at middle of ventral margin. Carapace in dorsal view lanceolate, widest at middle. Width nearly equal to height of carapace; shell subcircular in cross section at middle.

Length of holotype, 0.4 mm., height 0.16 mm., width 0.13 mm.

This species has been found only at the type locality, an exposure of the Littig member of the Kincaid formation, in contact with underlying Navarro clays, 3 miles northwest of Lone Oak, Hunt County, Texas. (Station 61, *Texas Univ., Bull.* 2907, p. 46, 1929.) It is very common at this locality.

Genus PARACYPRIS Sars, 1865

Carapace in side view, long, narrow. Rounded anteriorly, produced and tapering to an acute angle posteriorly. Valves subequal, the left being slightly larger than the right. Shell compressed, in dorsal view lanceolate; ends acute to subacute. Hinge simple.

Marginal zone of shell narrow, pore-canals few in number and widely spaced, straight and simple. Inner margin parallel to, but at considerable distance from, line of concrescence at anterior and posterior ends, coinciding with it for a short distance along the anterior one-third of the ventral margin (Pl. 35, fig. 9).

Muscle-scar area roughly circular, near center of valves. Muscle scars in genotype, six in number. A long, narrow scar is situated at the top of the muscle-scar area, and the other five scars form two vertical rows, three scars in the anterior row and two in the posterior. The species found in the Midway exhibits the same arrangement of the muscle scars as the genotype, but the scars differ slightly in shape.

Genotype, *Paracypris polita* Sars.

PARACYPRIS PERAPICULATA Alexander, n. sp.
Plate 32, figure 18; Plate 35, figures 9, 15

Carapace in side view elongate, highest at antero-cardinal angle, tapering strongly posteriorly. Dorsal margin gently arched, nearly straight along hinge line, obscurely angled at ends of hinge-line. Ventral margin almost straight, slightly sinuate at middle. Anterior end broadly and somewhat obliquely rounded. Posterior end slender, tapering, acute. In dorsal view narrow, lanceolate, widest at about anterior one-third of length; anterior end somewhat less acute than posterior. Surface smooth.

Length of holotype, 1.07 mm., height 0.37 mm., width 0.28 mm.

P. perapiculata is a rare form, occurring in outcrops of both the Kincaid and Wills Point clays.

Type locality, station 21.

Family BAIRDIDAE Sars, 1887

Genus BAIRDIA McCoy, 1844

Carapace of most species triangular or rhomboidal in outline. Left valve conspicuously larger than right, and overlapping it both dorsally and ventrally. Surface smooth or punctate. The posterior portion of the ventral margin in some species bears minute denticles, either on one valve or on both. Hinge structure simple, without teeth.

Marginal zones moderately broad, pore-canals numerous, closely spaced. The shell is so thick that it has been impossible to find specimens in which the pore-canals are readily discernible, even when isolated valves are embedded in Canada balsam. Inner margin parallels outer margin, and lies only a short distance within the line of concrescence.

Muscle-scar area circular, located slightly below middle of valves. Muscle scars numerous, small, and of somewhat variable shape and disposition.

Genotype, *Bairdia curta* McCoy.

BAIRDIA MAGNA Alexander

Bairdia magna ALEXANDER, *1927*, Jour. Paleontology, vol. 1, p. 32, pl. 6, figs. 7, 8; ALEXANDER, *1929*, Texas Univ., Bull. 2907, p. 63, pl. 3, fig. 8.

This large species, which occurs frequently in exposures of the Navarro clays of the Upper Cretaceous in Texas and in equivalent strata through the Gulf Coast region, occurs also in the Midway formations. It is somewhat more common in the Kincaid formation than in the Wills Point.

This, and similar species from the Cretaceous and Tertiary, have been included by most writers under the name *Bairdia subdeltoidea* (Münster). The latter species was described by Münster from Tertiary strata exposed near Osnabruck, Germany, from Paris and Bordeaux in France, and from Castel-Arquato in Italy.[18] Other considerations being favorable the first-named locality should be regarded as the type locality for the species. Through the courtesy of Dr. E. Jaworski, of the University of Bonn, Bonn am Rhein, Germany, the writer has procured a sample of the Upper Oligocene marine sand from Osnabruck. It has, therefore, been possible to compare the Navarro and Midway forms of *B. magna* Alexander with topotype specimens of *B. subdeltoidea* (Münster). The two species are similar in the degree of convexity of the dorsal and ventral margins, but *B. magna* is higher in proportion to the length of the shell and is distinctly blunter, or less distinctly angled, at the posterior end.

BAIRDIA SUBORBICULATA Alexander, n. sp.
Plate 32, figure 12

Carapace in side view subcircular in outline. Dorsal margin strongly and roundly arched, with no trace of angulation at highest point of arch. Ventral margin strongly and evenly convex downward. Anterior end broadly rounded, very slightly oblique. Posterior end not produced, angulation obscure. Left valve overlapping the right strongly along both dorsal and ventral margins. Valves strongly and evenly convex. Surface smooth, finely and distinctly punctate.

Length of holotype 1.15 mm., height 0.82 mm., width 0.62 mm.

This species is similar in size and in outline to *B. magna* Alexander, but is readily distinguished by the more nearly circular outline.

B. suborbiculata is fairly common in some outcrops of the Wills Point clays, but is rare in most exposures. It has not been observed in the Kincaid fauna.

Type locality, station 21.

Family CYTHERIDAE Baird, 1850

Genus BRACHYCYTHERE Alexander, 1933

Carapace oblong quadrate in outline. Dorsal margin more or less strongly arched, highest at or in front of middle. Anterior end compressed, broadly rounded, denticulate, bearing no distinctly thickened marginal rim. Posterior end compressed, narrower than anterior end, rounded or more or less acute, in most species denticulate along lower half. Carapace strongly convex, widest ventrally; ventral surface flat or nearly so, giving carapace a triangular appearance in end view or in cross section. Some species bear strong, wing-like lateral expansions of the shell at the ventro-lateral margins. Left valve conspicuously larger than right, and overlapping it distinctly along the entire dorsal margin.

Hinge structure of right valve consists of a strong, knoblike anterior tooth and postjacent socket, a slight furrow extending the length of the hinge margin, and a compressed, finely serrate posterior tooth. Corresponding to the anterior tooth and postjacent socket of the right valve, the hinge margin of the left valve bears a deep anterior socket, and immediately behind it, a strong, knob-like tooth. A strong ridge or bar, which is below and free of the dorsal margin of the shell except at its posterior

[18] Münster, G., Ueber einige fossile Arten *Cypris* und *Cythere: Jahrb. für Mineral. Geogn., Geol. Petrefackt.*, vol. 1, p. 64, 1830.

end, extends posteriorly from this tooth, and joins the dorsal margin of the valve in front of the long, narrow, notched socket which corresponds to the serrate posterior tooth of the right valve.

Marginal zones of shell moderately broad, pore-canals numerous and closely spaced, especially in antero-ventral region, where they are frequently branching and anastomosing. Most of the pore-canals are somewhat widened near the outer margin of the shell. Inner margin and line of concrescence coincide throughout.

Muscle-scar area situated slightly in front of middle of valves. Muscle scars six in number; the arrangement and shape of the individual scars appears to be a distinctive feature of the genus.

The hinge structure, the arrangement of the pore-canals in the marginal zones of the shell, and the muscle-scar pattern of the genotype are figured in detail in the original generic description.[19]

Genotype, *Cythere sphenoides* Reuss.

BRACHYCYTHERE PLENA Alexander, n. sp.
Plate 33, figure 6

Carapace in side view, oblong ovate, highest near anterior end. Dorsal margin gently arched, almost straight along hinge line. Ventral margin gently convex downward. Anterior end broadly rounded, posterior end narrow, rounded. Ventro-lateral edge of valves bears fine, narrow ridge, which in some individuals is obscure and almost imperceptible. Immediately above the anterior end of this ridge, the right valve bears a curved, somewhat crescent-shaped depression. Surface of valves finely and discretely punctate.

Length of holotype, 1.15 mm., height 0.68 mm., width 0.65 mm.

B. plena is very similar to *B. sphenoides* (Reuss), but is distinguished by (1) the lower ratio of height to length of the carapace, (2) the blunter posterior end, and (3) the more evenly rounded, less oblique anterior end. It appears to be even closer to *B. triangularis* (Reuss),[20] but neither the original figure or any subsequent figures of that species show the distinct depression above the anterior end of the low, narrow, ventro-lateral ridge which characterizes *B. plena* n. sp.

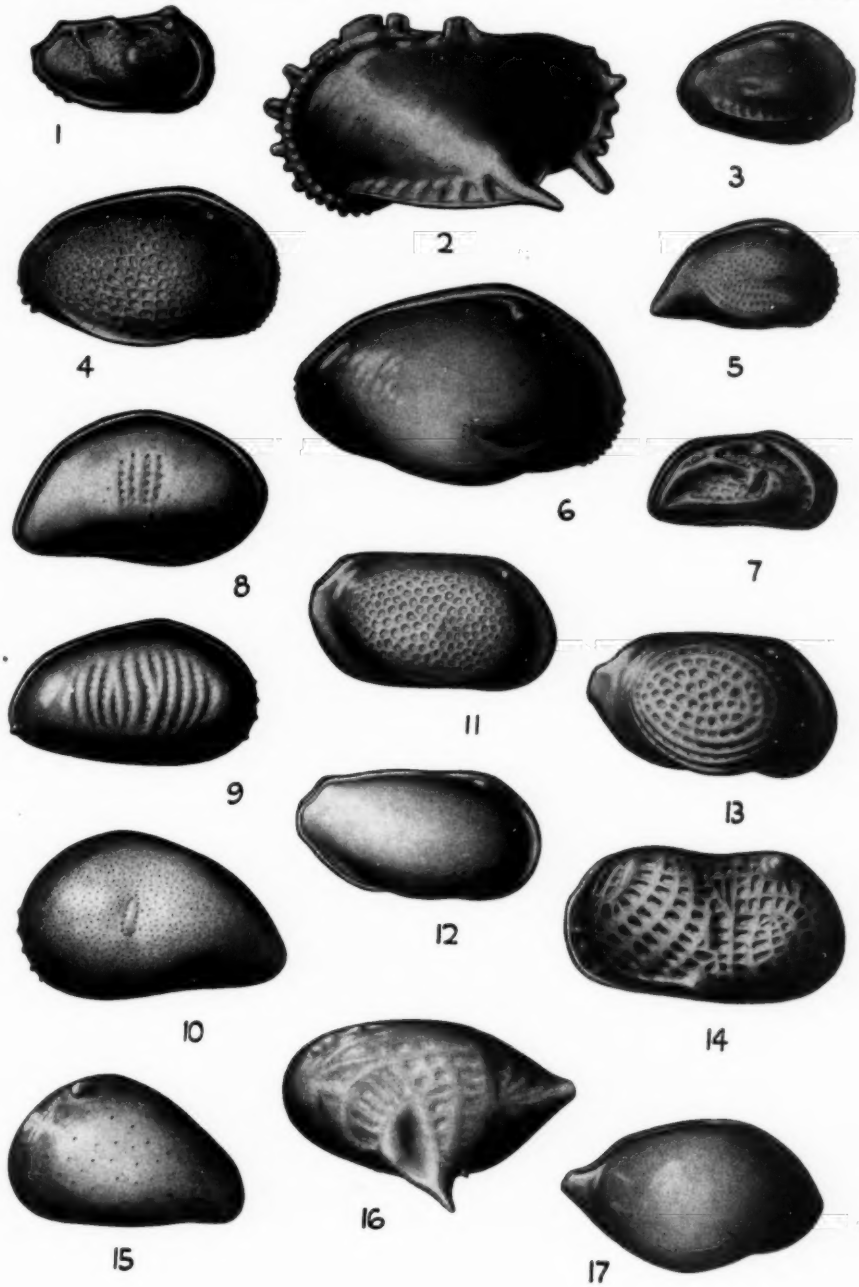
This species is one of the most distinctive and most reliable markers of the Midway group. It occurs in considerable

[19] Alexander, C. I., Shell structure of the ostracode genus *Cytheropteron*, and fossil species from the Cretaceous of Texas: *Jour. Paleontology*, vol. 7, p. 204, pl. 25, figs. 3*a*, *b*; pl. 26, figs. 7*a*, *b*; pl. 27, fig. 19, 1933.

[20] Reuss, A. E., Ein Beitrag zur Kenntniss der Kreidegebilde Meklenburgs: *Zeits. deutsch. geol. Gesell.*, vol. 7, p. 279, pl. 10, fig. 3, 1855.

EXPLANATION OF PLATE 33

FIGS. 1—*Cythereis midwayensis* Alexander, n. sp.; right valve view. (p. 219)
2—*Cythereis* (*Pterygocythereis*) *lemnicata* Alexander, n. sp.; right valve view. (p. 222)
3—*Brachycythere formosa* Alexander, n. sp.; right valve view. (p. 217)
4—*Brachycythere interrasilis* Alexander, n. sp.; right valve view. (p. 217)
5—*Brachycythere foraminosa* Alexander, n. sp.; right valve view. (p. 218)
6—*Brachycythere plena* Alexander, n. sp.; right valve view. (p. 216)
7—*Cytheridea ruida* Alexander, n. sp.; right valve view. (p. 224)
8—*Cytheridea fornicata* Alexander, n. sp.; right valve view. (p. 226)
9—*Cytheridea ruginosa* Alexander, n. sp.; right valve view. (p. 224)
10—*Cytheridea multipunctata* Alexander, n. sp.; lateral view, left valve. (p. 226)
11—*Loxoconcha perdecora* Alexander, n. sp.; right valve view, ×80. (p. 228)
12—*Loxoconcha nuda* Alexander, n. sp.; right valve view, ×80. (p. 228)
13—*Loxoconcha corrugata* Alexander, n. sp.; right valve view, ×80. (p. 228)
14—*Loxoconcha prava* Alexander, n. sp.; lateral view, right valve, ×80. (p. 228)
15—*Eucythere midwayensis* Alexander, n. sp.; lateral view, left valve, ×80. (p. 227)
16—*Cytheropteron aligerum* Alexander, n. sp.; lateral view, left valve, ×95. (p. 230)
17—*Cytheropteron midwayensis* Alexander, n. sp.; right valve view, ×60. (p. 230)
All figures ×40, unless otherwise indicated.



Alexander, Eocene ostracodes

abundance in most outcrops of both the Kincaid and Wills Point clays.

Type locality, station 7.

BRACHYCYTHERE INTERRASILIS
Alexander, n. sp.
Plate 33, figure 4

Carapace in side view ovate in outline, highest near anterior end. Dorsal margin arched, flattened along hinge line. Ventral margin gently and evenly convex downward. Anterior and posterior ends rounded, posterior narrower than anterior; anterior end minutely denticulate, posterior bearing three to four short, stout spines along inferior border. Valves strongly convex, widest ventrally, ventral surface broad and flat. Ventro-lateral edge of valves bears a strong, high, curved, longitudinal ridge. The surface of a narrow area at the anterior end of the shell is marked by a fine, strong, dense punctation. The remainder of the valve surface is strongly and coarsely reticulate, the meshes becoming finer near the dorsal, anterior, and posterior margins of the shell.

Length of holotype, 0.9 mm., height 0.53 mm., width 0.49 mm.

This species is closely similar to *B. subconcentrica* (Alexander)[21] from the Lower Cretaceous of Texas. In the present species, however, the greatest height of the carapace lies nearer the anterior end, the reticular ridges are thicker and heavier, and the ventro-lateral ridge is higher and stronger than in the Lower Cretaceous form.

B. interrasilis like *B. plena*, n. sp., is found in both the Kincaid and Wills Point clays, but is of even greater value as a marker, because of its striking appearance.

Type locality, station 7.

BRACHYCYTHERE FORMOSA Alexander, n. sp.
Plate 33, figure 3

Carapace in side view, oblong ovate, highest at anterior end, tapering strongly posteriorly. Dorsal margin arched, flattened and nearly straight along hinge line. Ventral margin straight. Anterior end compressed, broadly rounded, bearing a broad, thin, marginal keel. This keel is so thin and fragile that it is partially or wholly destroyed in all individuals observed. Posterior end compressed, narrow, obtusely angled. The elongated, obliquely disposed anterior cardinal tubercle is connected at its upper end to a low, rounded ridge which continues backward along the dorsal margin, becoming lower and less distinct posteriorly. A second low, rounded ridge arises a short distance below and behind the anterior cardinal tubercle and extends obliquely backward and upward to join the dorsal marginal ridge at about the middle of the hinge margin. A broad, low, obscure subcentral node gives rise to a low ridge which extends backward for a short distance along the median longitudinal line. The ventro-lateral edge of the valve bears a high, strong, longitudinal ridge which bears a row of strong pits along its upper surface, and which terminates posteriorly in a short, sharp backward-projecting angle. Surface of valves with a few large, widely spaced, shallow pits.

Length of holotype, 0.6 mm., height 0.42 mm., width 0.33 mm.

The form of the shell and surface sculpture of this species are of a very unusual type for a member of this genus. The subcentral node and the median longitudinal ridge behind it give a striking resemblance to species of *Cythereis*. The absence of a thickened marginal rim, and especially the pronounced overlapping of the left valve along the entire dorsal margin, rather than at the anterior cardinal angle only, and the distinctive and characteristic hinge structure establish it as a member of the genus *Brachycythere*.

B. formosa has been found only in the Wills Point, and is fairly common in most outcrops of this formation. It is one of the few species common in one of the

[21] Alexander, C. I., Ostracoda of the Cretaceous of North Texas: *Texas Univ., Bull.* 2907, p. 79, pl. 6, figs. 9, 10, 1929.

formations of the Midway group, and entirely absent in the other.

Type locality, station 21.

BRACHYCYTHERE FORAMINOSA
Alexander, n. sp.
Plate 33, figure 5

Carapace in side view subtriangular, highest slightly in front of middle. Dorsal margin strongly arched, nearly straight and sloping steeply downward and backward along hinge line. Ventral margin nearly straight, with slight sinuosities near each end. Anterior end broadly and obliquely rounded, finely denticulate. Posterior end strongly compressed, triangular in form, with acute postero-ventral angle; ventral border straight, in direct continuation with ventral margin of shell, finely denticulate. Valves strongly convex. Ventro-lateral edge of valve slightly inflated to form a broad, rounded, indistinct ridge. Above this ridge, in the anterior half, is a broad, shallow furrow which becomes obsolete toward the compressed anterior end of the shell. A slight nodelike swelling lies at the middle of the valve above the posterior end of this furrow. The entire surface of the shell is strongly marked with small, deep pits, which are largest and deepest near the center of the valves, and become smaller near the margins. Length of holotype, 0.66 mm., height 0.37 mm., width 0.37 mm.

B. foraminosa n. sp. is similar in form to *B. ledaforma* (Israelsky)[22] from the Upper Cretaceous of Arkansas and Texas,[23] and is obviously a descendant of that species. It is most readily differentiated by the strongly pitted valve surfaces, but is also distinctly higher in proportion to length of carapace, has a more acute posterior end, a straight, instead of a gently convex ventral margin, and is distinctly smaller than its Upper Cretaceous ancestor.

B. foraminosa has been found only in the Littig member at the base of the Kincaid formation, northwest of Lone Oak, Hunt County, Texas, station 22.

Genus CYTHEREIS Jones, 1849

The members of this genus exhibit greater variation in form and surface sculpture than any other genus of the Ostracoda. Certain fundamental generic characters, however, are shared by all of the enormously varied species assignable to the genus.

The carapace is characteristically highest at the anterior end. The dorsal margin is straight, except for a more or less abrupt downward curve or slope immediately behind the high, rounded, antero-dorsal angle. Ventral margin straight or nearly so, dorsal and ventral margins subparallel, converging slightly posteriorly. Anterior end rounded, denticulate, and in most species bearing an elevated marginal rim or flange. This marginal rim continues backward along the dorsal and ventral margins in most of the species in which it is present, and the ridges thus formed usually terminate posteriorly in more or less strongly elevated knobs or spinose processes. Posterior end strongly compressed, more or less distinctly triangular in form, denticulate along lower border, and like the anterior end, bearing a marginal rim in most species. Left valve larger than right, but overlapping it conspicuously only at the high, antero-dorsal angle, and somewhat less conspicuously along the dorsal border of the posterior end.

In most species, the carapace is distinctly flattened at both the dorsal and ventral margins and has a roughly quadrangular cross-section. The ventral surface is, as a rule, broader than the dorsal, and in some species is greatly expanded by the presence of broad, compressed, winglike lateral processes at the ventro-lateral edges of the valves. Blake[24] has

[22] Israelsky, M. C., Upper Cretaceous Ostracoda of Arkansas: *Arkansas Geol. Survey, Bull.* 2, p. 8, pl. 1A, figs. 5–7, 1929.

[23] *Cythere acutocaudata* Alexander, Ostracoda of the Cretaceous of North Texas: *Texas Univ. Bull.* 2907, p. 87, pl. 7, figs. 5, 6, 1929.

recently established a new subgenus, *Pterygocythereis*, for these alate species of the genus *Cythereis*.

A more or less strongly elevated, rounded tubercle is present slightly in front of the center of the valves in most species of *Cythereis*. In some, however, it is obscured by a median longitudinal ridge, and in the alate representatives of the subgenus *Pterygocythereis*, is entirely absent.

The hinge structure consists, in the right valve, of a knoblike anterior tooth and postjacent socket, a shallow furrow extending the length of the hinge margin, and a posterior tooth. The posterior tooth, in most species, is rounded and knoblike, but in some is more or less strongly compressed, and in a few, strongly compressed and serrate, as in *Brachycythere*. Corresponding to these structures of the right valve, the hinge margin of the left valve bears a deep anterior socket and postjacent, knoblike tooth, and a posterior socket. The straight dorsal edge of the valve is elevated to form a flange or ridge which fits into the shallow groove in the hinge margin of the right valve. There is no bar or ridge below and distinct from the dorsal edge of the valve itself, and in this respect the hinge structure of the genus *Cythereis* differs most strongly from that of *Brachycythere*.

Line of concrescence at a moderate distance from the outer margin of the shell. Inner margin and line of concrescence coincide throughout, except for a very slight divergence in the lower half of the anterior margin. Pore-canals as in *Brachycythere*. The thick shell and strong surface sculpture so obscure the muscle-scar pattern, that the writer has been unable to determine the details of this structure, except for a species of the subgenus *Pterygocythereis*. The muscle-scar pattern, and other finer details of shell structure of *Cythereis* (*Pterygocythereis*) *lemnicata*, n. sp. are figured on Plate 35, figures 10 and 11.

CYTHEREIS MIDWAYENSIS Alexander, n. sp.
Plate 33, figure 1

Carapace oblong, highest in front. Dorsal margin straight, ventral margin nearly straight, very slightly convex downward. Anterior end broadly rounded, rimmed, finely denticulate. Posterior end compressed, triangular in form, blunt; postero-ventral border gently convex, denticulate, postero-dorsal border slightly concave. Anterior marginal rim continues backward to about middle of dorsal margin, and there ends abruptly. A second ridge arises, just below and free of the posterior end of the first, extends obliquely upward and backward a short distance to the dorsal margin, and continues around the entire periphery of the valve as a thick, rounded, marginal rim, joining the anterior rim at the antero-ventral angle. At this point, another ridge branches from the anterior marginal rim and continues backward along the ventro-lateral edge of the valve. At a point slightly behind the middle of the ventral margin, this ridge curves upward, and continuing obliquely and irregularly upward and backward, joins the dorsal marginal rim just in front of the compressed posterior end. Surface of valves bears a high, round subcentral tubercle, and a more or less distinct, coarse reticulation. In some individuals the reticulation is strong, in others it is obscure on either a part or on all of the surface.

Length of holotype, 0.65 mm., height 0.35 mm., width 0.37 mm.

C. midwayensis is closely similar in both form and surface ornamentation and is obviously closely related to *C. bassleri* (Ulrich) from the Eocene of Maryland.[25] Through the courtesy of Dr. R. S. Bassler, of the United States National Museum, the writer has procured

[24] Blake, Charles, "Ostracoda," in Biological Survey of the Mount Desert Region, Pt. 5, p. 239, 1933.

[25] Ulrich, E. O., Ostracoda: *Maryland, Geol. Survey*, Eocene volume, p. 120, pl. 16, figs. 19–21, 1901.

specimens of *C. bassleri* from the type locality for the species. The Maryland species is characteristically larger than the Texas Midway form, the posterior end is much shorter and more obtuse, and the surface reticulation is stronger and much coarser. Further, in *C. bassleri* the ventro-lateral ridge extends backward to the compressed posterior end, from which position it turns abruptly upward, nearly at right angles, and extends almost vertically, instead of obliquely, upward, joining the dorsal marginal ridge at the postero-cardinal angle. A distinct median-longitudinal ridge extends posteriorly from the subcentral tubercle in *C. bassleri*, and joins this nearly vertical, transverse ridge a short distance below the posterior cardinal angle.

It is the writer's opinion that *C. midwayensis* n. sp. is the direct ancestor of *C. bassleri* (Ulrich), and of similar or identical forms which have been observed in strata of Wilcox and Claiborne age in Texas, Louisiana and Alabama.

C. midwayensis is very abundant in nearly all outcrops of the Kincaid formation, and occurs less abundantly in most outcrops of the overlying Wills Point clays.

Type locality, station 7.

CYTHEREIS SPINIFERRIMA Jones and Sherborn
Plate 32, figure 11

Cythereis spiniferrima JONES and SHERBORN, *1889*, Suppl. Monogr. Tertiary Entom. England, Paleont. Soc. London, p. 34, text-figure 3.

Carapace distinctly oblong, highest in front. Dorsal and ventral margins straight, converging posteriorly. Anterior end rounded, strongly rimmed, bearing a double row of short, sharp spines. Posterior end compressed, triangular in form, acutely angled at middle, finely denticulate along upper border and bearing three or four long, stout, outward- and downward-projecting spines along the lower border. Surface of valves coarsely reticulate, with scattered spinose projections arising from the junctions of the ridges of the meshes. The spines are somewhat longer near the dorsal and ventral borders, and the reticulation distinctly coarser near the anterior end of the shell.

Length of plesiotype 0.69 mm., height 0.45 mm., width 0.28 mm.

C. spiniferrima Jones and Sherborn is similar in some respects to *C. ornatissima* (Reuss),[26] a species occurring in the Upper Cretaceous in many parts of the world. In the latter species, however, the dorsal and ventral margins are subparallel, converging but slightly posteriorly, the carapace is widest at the ventral margin instead of at the median longitudina line, and the ventro-lateral edge of the valves bears a distinct ridge, which is absent in *C. spiniferrima*. The present species, also, is more strongly compressed, and bears longer spines at the junctions of the reticular ridges than *C. ornatissima*.

C. spiniferrima Jones and Sherborn is an abundant species in both the Kincaid and Wills Point formations.

Plesiotype, collected at station 21.

CYTHEREIS PRESTWICHIANA
Jones and Sherborn
Plate 32, figures 14, 15

Cythereis prestwichiana JONES and SHERBORN, *1887*, Geol. Mag., p. 454, pl. 11, figs. 11*a*, *b*; JONES and SHERBORN, *1889*, Suppl. Monogr. Tertiary Entom. England, Paleont. Soc. London, p. 33, pl. 2, figs. 13, 14.

Carapace oblong, highest in front. Dorsal and ventral margins straight, subparallel, converging slightly posteriorly. Anterior end rounded, rimmed, denticulate. Posterior end bluntly angled at about middle, bearing four or five short, stout teeth along lower margin. Continuations of the anterior marginal rim extend, ridge-like, along the dorsal and ventral borders of the valves; ventral ridge more strongly elevated than dorsal. Both ridges terminate posteriorly in sharp rectangles, immediately in front of the compressed posterior end. An ob-

[26] Reuss, A. E., Verstein. böhm. Kreidef., pt. 2, p. 104, pl. 24, figs. 12, 18, 1846.

scure subcentral node forms the anterior end of a short, narrow, median longitudinal ridge which, near the posterior end, turns obliquely upward to join the down-turned end of the dorsal marginal ridge. Surface of valves covered with a distinct, but delicate, lacelike reticulation.

Length of plesiotype, 0.6 mm., height 0.33 mm., width 0.28 mm.

This small species is somewhat similar in appearance to *C. mahonae* Alexander, *C. worthensis* Alexander and *C. austinensis* Alexander, described from the Cretaceous of Texas.[27] It differs from all three of these species, however, in the character of the reticulation which marks the valve surfaces. In *C. prestwichiana* the ridges of the meshes give off numerous short, sharp spurs that project into the enclosed pits, giving a distinctly lacy appearance to the reticulation. It also differs from each of these in other details of sculpture. For example, there is no subcentral node in *C. mahonae* nor in *C. worthensis*, the long, median ridges that characterize these species arising near the anterior end of the shell. The dorsal and ventral marginal ridges of *C. austinensis* arise within and free of the ends of the anterior marginal rim, instead of being direct continuations of it.

The type figures of *C. prestwichiana* Jones and Sherborn do not indicate a connection between the median and dorsal ridges, such as the writer has observed in the Midway specimens. The connecting ridge in the Midway forms is often low and obscure, however, and the published figures of *C. prestwichiana* obviously are somewhat generalized. The Midway specimens fit both the description and figures of *C. prestwichiana* so perfectly in every other respect that the writer does not feel justified in naming a new species.

This striking species occurs in abundance in most outcrops of both the Kincaid and Wills Point clays.

Plesiotype, collected at station 21.

CYTHEREIS CANCELLOSA Alexander, n. sp.
Plate 32, figure 10

Carapace strongly compressed, oblong quadrate in outline. Dorsal and ventral margins straight, subparallel. Anterior end rounded, bearing a high, narrow, marginal flange and eight to ten coarse, flat, blunt teeth. Anterior marginal rim bears a row of small pits at its crest, and continues backward along the dorsal and ventral borders of the valves. Dorsal ridge bends downward in a sharp rectangle at the posterior cardinal angle, forming a short, strongly elevated vertical ridge which terminates abruptly before attaining the median line of the shell; ventral ridge continues around the somewhat produced and acutely angled posterior end. The slightly convex lower border of the posterior end bears four or five strong, flat teeth like those of the anterior end. A short, high, narrow ridge is situated just above and parallel to the posterior half of the ventral ridge. A less strongly elevated ridge extends obliquely backward and upward from a point slightly in front of the center of the valves and joins the short, vertical ridge of the posterior cardinal angle at about its middle. Surface of valves strongly reticulate.

Length of holotype 0.77 mm., height 0.35 mm., width 0.27 mm.

C. cancellosa appears as a rare form in most outcrops of both the Kincaid and Wills Point formations.

Type locality, station 9.

CYTHEREIS SCULPTILIS Alexander, n. sp.
Plate 32, figure 13

Carapace oblong, highest in front. Dorsal margin sloping gradually downward from anterior end, straight in posterior half. Ventral margin straight, paralleling posterior half of dorsal margin. Anterior end broadly rounded, bearing narrow marginal rim and a broad, thin marginal keel. Posterior end compressed, bluntly

[27] Alexander, C. I., Ostracoda of the Cretaceous of North Texas: *Texas Univ., Bull.* 2907, p. 90, pl. 7, fig. 7; p. 92, pl. 7, figs. 8, 12; p. 99, pl. 7, fig. 11, 1929.

angled at middle. Anterior marginal rim continues backward along ventral and around posterior margins of valves. Posterior half of dorsal margin bears a low, rounded ridge. A long, median ridge is surmounted near the middle of its length by a distinct, subcentral node, and a shorter ridge lies just above, and parallel to, the ventral marginal ridge. Surface of valves smooth.

Length of holotype 0.6 mm., height 0.33 mm., width 0.25 mm.

C. sculptilis is a rare form occurring in some outcrops of both Kincaid and Wills Point clays, and is represented somewhat more frequently in the latter.

Type locality, station 21.

CYTHEREIS (PTERYGOCYTHEREIS) LEMNICATA Alexander, n. sp.

Plate 33, figure 2; Plate 35, figures 10, 11.

Carapace in side view oblong, quadrate, highest in front. Dorsal and ventral margins straight, subparallel, converging slightly posteriorly. Anterior end broadly rounded, bearing a low, narrow, rounded marginal rim and eight to ten long, flat teeth. Posterior end somewhat narrower than anterior, rounded, bearing long, stout, hollow, spinelike teeth along the lower margin. Valves bear strongly projecting, winglike lateral expansions at ventral margins. Alaeform processes have broad, strongly compressed, bladelike marginal zones. Anterior border of wings slightly concave in anterior half, convex in posterior half; posterior border concave, postero-lateral angle bearing strong, tapering, slightly curved spines. A row of small pits is situated at the base of the wing on the dorsal surface. Dorsolateral edge, bounding narrow, flattened dorsal area, bears a row of four or five short, broad, compressed, dorsally projecting, toothlike processes. Surface smooth.

Length of holotype (left valve), 1.25 mm., height 0.7 mm., width (including tip of lateral spine) 0.68 mm.

C. (*P.*) *lemnicata* occurs in both the Kincaid and Wills Point formations, and, though everywhere rare, is somewhat more frequent in the Wills Point.

Type locality, station 21.

Genus CYTHEROMORPHA Hirschmann, 1901

Carapace elongate, highest at anterocardinal angle. Dorsal margin long, nearly straight, very slightly convex, with distinct, rounded angles at junction with anterior and posterior ends. Ventral margin nearly straight, slightly sinuate at middle. Dorsal and ventral margins converge distinctly posteriorly. Anterior end broadly and obliquely rounded, with very narrow, compressed border. Posterior end narrower than anterior, rounded. Carapace more or less strongly compressed, posterior portion of female shell slightly broader than that of male.

Hinge structure consists in right valve, of three small, but distinct teeth, one at the anterior end and two at the posterior. The anterior tooth lies at a slight distance below the dorsal edge of the valve, and is just below the anterior end of a narrow, shallow groove that extends the length of the hinge margin. The two posterior teeth are separated by a small, deep socket. The hinge margin of the left valve bears an anterior tooth, which articulates in front of the anterior tooth of the right valve, and a posterior tooth, with deep sockets on each side of it.

Line of concrescence runs very near and parallel to the outer margin of the shell. The inner margin also parallels the outer margin; at the anterior end it is about twice the width of the marginal zone from the outer margin, coincides with the line of concrescence at the anterior third of the ventral margin, and along the remainder of the ventral margin and at the posterior end lies slightly within the line of concrescence.

Pore-canals very few and widely spaced, narrow, straight, simple, without bulbous enlargements.

Through the courtesy of Dr. Paul

Loyning, Curator of Marine Invertebrates at the Museum of the University of Oslo, Oslo, Norway, the writer has obtained specimens of the type species of the genus *Cytheromorpha*, and the figures illustrating the shell characters of this genus have been drawn from these specimens (Pl. 34, figs. 11, 12; Pl. 35, fig. 19).

Genotype, *Cythere fuscata* Brady.

CYTHEROMORPHA SCROBICULATA
Alexander, n. sp.
Plate 32, figure 19

Carapace in side view narrow, elongate, highest at anterior end. Dorsal margin nearly straight, very slightly arched. Ventral margin slightly sinuate near middle. Anterior end obliquely rounded. Posterior end much narrower than anterior, bluntly rounded. Surface of valves except for narrow zone near anterior end, coarsely and strongly pitted, and with two low, short, longitudinal plications; one of these plications is curved slightly upward and lies near the median longitudinal line of the valves, the other is straight, and is near the ventral margin. A narrow, crescent-shaped area at the anterior end of the shell is smooth except for a few low, narrow, radiating ridges.

Length of holotype 0.43 mm., height 0.22 mm., width 0.09 mm. (single valve).

This distinctive little species, which is the first representative of the genus recorded as fossil, occurs as a rare form in both the Kincaid and Wills Point formations.

Type locality, station 7.

Genus CYTHERIDEA Bosquet, 1852

Carapace in side view subtriangular, highest at or in front of middle. Anterior end rounded, denticulate. Posterior end abruptly tapering, with subacute to broadly rounded postero-ventral angle, usually denticulate along ventral border. Valves unequal in size, the left valve being larger than and overlapping the right around the entire periphery.

Hinge consists in right valve of two elongated teeth, one at each end of the hinge line, each bearing several cusps, and connected by a narrow, finely crenulate bar. In the left valve are notched sockets, corresponding to the terminal teeth of the right valve. A narrow bar is attached at each end to the dorsal margin of the valve at a point just above the middle of the terminal sockets, but lies below, and is separated by a rather distinct groove from the dorsal margin, except at the ends. This bar and groove are very distinct in species characterized by a strongly arched dorsal margin but are somewhat obscure in elongated species with a low, flat dorsal arch. Below the bar is a finely pitted groove, which connects the notched terminal sockets, and into which fits the crenulate bar of the right valve. The hinge structure of this genus has been figured in a previous paper by the writer.[28]

Inner margin and line of concrescence coincide except for a slight deviation at the anterior end, and are fairly near and parallel to the outer margin of the shell. The radial pore-canals are numerous and closely spaced; most of them are simple, although a few are branched.

Müller[29] describes the muscle-scar pattern of Recent species of *Cytheridea* as consisting of a vertical row of four small scars, with a fifth in front of these. In all the fossil species examined by the writer, there are two spots instead of one in front of the row of four.

CYTHERIDEA EVERETTI Berry

Cytheridea everetti BERRY, *1925*, Am. Jour. Sci., 5th ser., vol. 9, p. 486, fig. 9.–ALEXANDER, *1929*, Texas Univ., Bull. 2907, p. 74, pl. 5, figs. 9, 10.

This species, described by Berry from the Monmouth formation of Maryland, and reported by Alexander from the Navarro of Texas, is represented by rare individuals in the Kincaid formation. In Kincaid specimens, the strong puncta

[28] Alexander, C. I., Shell structure of the ostracode genus *Cytheropteron*, and fossil species from the Cretaceous of Texas: *Jour. Paleontology*, vol. 7, pl. 26, figs. 4*a*, *b*, 1933.

[29] Müller, G. W., Die Flora und Fauna des Golfes von Neapel, Monogr. 21, Ostracoda, p. 359 1894.

near the center of the valves are arranged in two to four short, parallel, vertical rows. Many individuals from the Monmouth and Navarro formations exhibit this same tendency, but the arrangement is less distinct.

CYTHERIDEA FABAFORMIS (Berry)

Cytherella fabaformis BERRY, *1925*, Am. Jour. Sci., 5th ser., vol. 9, p. 487, fig. 13.

Cytheridea fabaformis ALEXANDER, *1929*, Texas Univ., Bull. 2907, p. 76, pl. 5, fig. 18.

This strongly sculptured little species, like the above, has been recorded from the Monmouth and Navarro formations, and occurs frequently in outcrops of the basal clays of the Kincaid formation. Most Kincaid specimens are somewhat larger and more robust than those from the underlying Navarro, but are otherwise identical in every respect.

A similar species has been observed in the Wilcox sandy clays outcropping near Ozark, Alabama. The Wilcox species is obviously derived from *C. fabaformis* (Berry), and is distinguished by the development of a high, broad, rounded, median longitudinal ridge in the posterior half of the shell, immediately above the short, shallow sulcus which characterizes both forms.

CYTHERIDEA RUIDA Alexander, n. sp.
Plate 33, figure 7

Carapace oblong, highest at anterior end. Dorsal margin straight except for slight downward slope immediately behind high antero-cardinal angle. Ventral margin nearly straight, with slight sinuosity in anterior third. Dorsal and ventral margins subparallel, converging slightly posteriorly. Anterior end rounded, strongly oblique. Posterior end obliquely truncated, with rounded, subacute postero-ventral angle. A strong, narrow ridge runs parallel to and a short distance within the anterior margin and continues backward along the ventral margin, becoming obsolete near the posterior end. A strongly elevated, narrow, elongated node, with its long axis vertically disposed, is situated about one-third of the length of the carapace from the anterior end. The lower end of this node is connected by a short, narrow, posteriorly curved ridge to the ventral marginal ridge, and the upper end gives rise to a strong, narrow ridge which extends posteriorly, slightly above the median longitudinal line of the shell, then, at a point about one-third of the length of the carapace from the posterior end, bends obliquely downward toward the postero-ventral angle and terminates near the posterior end, just above the posterior termination of the ventral ridge. A short distance behind its junction with the upper end of the vertically elongated anterior node, this longitudinal ridge gives rise to a short, narrow, ridge that extends vertically downward and terminates abruptly slightly above the middle of the ventral marginal ridge; at the point where it makes its oblique turn the longitudinal ridge gives rise to a second short ridge which extends vertically upward to the dorsal margin. Surface of valves between the ridges, rather strongly pitted.

Length of holotype 0.65 mm., height 0.42 mm., width 0.34 mm.

C. ruida is somewhat variable in degree of development of the pits that mark the valve surfaces. In some specimens, most of the pits are small and are conspicuous only along the bases of the strong ridges. In others, however, the entire surface between the ridges, and even the crests of the ridges themselves, may be strongly pitted.

This strongly ornamented and distinctive species has been found only in exposures of the basal clays and glauconitic clays of the Kincaid formation.

Type locality, station 1.

CYTHERIDEA RUGINOSA Alexander, n. sp.
Plate 33, figure 9

Carapace in side view elongate, triangular ovate, highest somewhat in front of middle. Dorsal margin gently arched, nearly straight along hinge line, with rounded, obscure antero- and postero-

cardinal angles. Ventral margin gently but distinctly convex downward. Anterior end broadly and evenly rounded. Posterior end with blunt, rounded posteroventral angle. Surface of valves strongly pitted, the puncta arranged in eight to eleven roughly parallel, vertical furrows, with narrow, rounded intervening ridges; the median two or three of these furrows are slightly deeper than the others and those near the ends of the shell become shallower and less distinct. Carapace strongly convex, widest at middle; in dorsal view, valve surfaces convex, anterior end broad, blunt, with narrow, compressed border, posterior end tapering slightly, blunt.

Length of holotype 0.87 mm., height 0.5 mm., width 0.4 mm.

C. ruginosa is somewhat similar to *C. monmouthensis* Berry, which has been recorded from the Monmouth formation of Maryland[30] and the Navarro of Texas,[31] to *C. mülleri* (Münster) from the Tertiary of Europe,[32] and to the species identified as *C. mülleri* by Cushman from the Eocene of Mexico[33] and by Stadnichenko from the so-called Yegua (now Crockett), Eocene, of Texas.[34] The writer has obtained specimens of *C. monmouthensis* from the Monmouth formation of Maryland, of *C. mülleri* from the type locality, an exposure of Oligocene clays near Osnabrück, Germany, and of the species described under the latter name by Cushman and Stadnichenko from the original collections of these writers.

C. ruginosa is readily distinguished from *C. monmouthensis* Berry by the more elongate form and by the more numerous and more strongly developed vertical furrows with their rows of pits.

In the true *C. mülleri* (Münster), the ventral margin is less convex downward, the dorsal and ventral margins are more nearly parallel, and the vertical rows of pits are fewer in number and the furrows less distinct than in *C. ruginosa*. In dorsal view the posterior end is much broader and more obtuse than in *C. ruginosa*.

Miss Stadnichenko has included two separate and distinct species under the name *C. mülleri* (Münster); one of these is specifically identical with the specimens referred by Cushman to the same species, from the Eocene of Mexico, whereas the other is a peculiar form characterized by the presence of numerous small tubercles, instead of puncta, on the valve surfaces.

The punctate specimens from the Moctezuma River of Mexico and from the so-called Yegua (Crockett) of Texas are similar to *C. mülleri* (Münster) in having more nearly parallel dorsal and ventral margins than *C. ruginosa* n. sp. In dorsal view, also, the sides of the valves are flat, instead of convex, and the posterior end broad and blunt, like the anterior. They are characterized, however, by the presence of 12 to 15 vertical rows of distinct puncta, each row being situated in a deep furrow; *C. mülleri* exhibits even fewer and less distinct furrows than *C. ruginosa*. They differ further from *C. ruginosa* in that the furrows near the ends of the shell curve somewhat to parallel the anterior and posterior ends, rather than remaining straight and parallel to those near the center.

C. ruginosa is believed to be derived from *C. monmouthensis* Berry, and to be ancestral to the species described as *C. mülleri* (Münster) by Cushman and Stadnichenko.

C. ruginosa is represented by an abundance of individuals in nearly all outcrops of the Kincaid formation and oc-

[30] Berry, E. Willard, The Upper Cretaceous Ostracoda from Maryland: *Am. Jour. Sci.*, 5th ser., vol. 9, p. 486, fig. 10, 1925.

[31] Alexander, C. I., Ostracoda of the Cretaceous of North Texas: *Texas Univ., Bull.* 2907, p. 74, pl. 5, figs. 11–14, 1929.

[32] Münster, G., *Op. cit.*, p. 62.

[33] Cushman, Joseph A., An Eocene fauna from the Moctezuma River, Mexico: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 9, p. 301, pl. 8, figs. 4, 5, 1925.

[34] Stadnichenko, M., Foraminifera and Ostracoda of the marine Yegua of the type sections: *Jour. Paleontology*, vol. 1, p. 238, pl. 39, fig. 14, 1927.

curs in less abundance, in some outcrops of the Wills Point. The more strongly corrugated and punctate derivative of this species described by Cushman and Stadnichenko has been observed in samples collected from an outcrop of Wilcox sandy clays near Ozark, Alabama, and from numerous exposures of the Claiborne formations in Texas, Louisiana and Mississippi.

Type locality for *C. ruginosa* n. sp., station 6.

CYTHERIDEA FORNICATA Alexander, n. sp.
Plate 33, figure 8

Carapace in side view elongate, triangular ovate, highest at, or but slightly in front of, middle. Dorsal margin strongly and almost evenly arched, very obscurely angled at ends of hinge line. Ventral margin nearly straight, slightly convex downward in anterior half, slightly sinuate in posterior half. Anterior end rather low, somewhat narrowed, obliquely rounded, bearing six to eight short, fine teeth. Posterior end with blunt postero-ventral angle. Surface of valves finely punctate, the puncta near the center of the valves arranged in two to four short, parallel, vertical rows. Carapace in dorsal view strongly convex, widest near middle, ends subacute.

Length of holotype 0.9 mm., height 0.53 mm., width 0.42 mm.

This species has been collected only in outcrops of the Kincaid clays and is rare at most of the localities where it has been observed.

Type locality, station 22.

CYTHERIDEA MULTIPUNCTATA
Alexander, n. sp.
Plate 33, figure 10

Carapace in side view subtriangular, highest anteriorly. Dorsal margin strongly arched, obscurely angled at ends of hinge line. Ventral margin gently convex downward in anterior half, slightly sinuate in posterior half. Anterior end high, broadly rounded, bearing six to eight fine, short spines along lower margin. Posterior end with acute postero-ventral angle; ventral surface near posterior end with one to three small spines. Surface of valves finely and densely punctate, except for small, narrow, smooth area situated in a slight depression near the center of the valves, and corresponding in position to the muscle-scar area on the interior of the valves. The puncta immediately surrounding this smooth area are larger than those near the margins of the shell. In dorsal view, carapace widest slightly behind middle, ends similar, subacute.

Length of holotype 0.95 mm., height 0.58 mm., width 0.23 mm. (single valve).

This distinctively sculptured and easily recognizable species has been observed only in collections from the Wills Point clays. It is abundant in some outcrops, rare in others.

Type locality, station 21.

Genus EUCYTHERE Brady, 1866

Shell more or less distinctly triangular in outline, highest at anterior end, tapering strongly posteriorly. Hinge margin straight or nearly so. Ventral margin straight, or slightly sinuate near middle. Anterior end high, broadly rounded. Posterior end narrow, subacute to obtuse. Surface of valves smooth, except for the presence of a few large, conspicuous, widely spaced, normal pore-canals.

Hinge structure weakly developed. In the left valve a low, narrow bar extends the length of the hinge margin and is separated by a shallow, obscure groove from the dorsal edge of the valve. The right valve bears a more or less distinct groove for the reception of the narrow bar of the left valve, and at the posterior end of the hinge line is a long, low, narrow tooth, which fits into an obscure socket at the posterior end of the hinge margin of the left valve. The hinge structure is so poorly developed in many members of the genus that generic allocation is more easily and certainly made on the basis of other shell structures.

The line of concrescence is at a moderate distance from, and parallel to, the

outer margin of the shell. The inner margin lies at about twice the width of the marginal zone within the line of concrescence at the anterior end, coincides with the line of concrescence along the ventral margin, and deviates but slightly from it at the posterior end. The radial pore-canals are few, straight, and simple (Pl. 35, fig. 17).

The muscle-scar pattern consists of an oblique row of four small scars, with either one or two others in front of these. In the Tertiary and Recent species a single large scar lies in front of the row of four, and in some recently discovered Cretaceous species that appear to be referable to this genus, the writer has observed two smaller scars instead of one large scar.

Genotype, *Cythere declivis* Norman.

EUCYTHERE MIDWAYENSIS Alexander, n. sp.
Plate 33, figure 15

Carapace in side view distinctly triangular in shape, highest at anterior end. Dorsal margin straight along hinge line, sloping steeply posteriorly. Ventral margin straight. Anterior end broadly rounded. Posterior end narrow, bluntly rounded. Valves strongly and evenly convex. Surface smooth.

Length of holotype 0.42 mm., height 0.35 mm., width 0.12 mm. (single valve).

This species is represented in the writer's collections by a single valve, and is included in this paper because this specimen represents the earliest known occurrence of a species unquestionably referable to this genus. *E. midwayensis* exhibits in typical form all the generic characters of the genus *Eucythere*.

Type locality, station 21.

Genus LOXOCONCHA Sars, 1865

Shell rhomboidal to quadrate in outline, of nearly equal height throughout entire length. Dorsal margin long, straight, with distinct, rounded, antero- and postero-cardinal angles. Ventral margin straight or somewhat flexuous, curving upward posteriorly to the short, blunt, compressed caudal process, which is situated above the median longitudinal line of the shell. Postero-ventral edge of valves bears a narrow, compressed, bladelike keel. Anterior end obliquely rounded. Surface of valves usually pitted or reticulate, in some species smooth. In most species a distinct anterior cardinal tubercle is present over the anterior end of the hinge line.

The hinge structure consists, in the right valve, of an anterior socket and knoblike postjacent tooth, a shallow furrow extending the length of the hinge margin, and a posterior tooth. The posterior tooth is pecular in form, consisting of a knoblike posterior portion, which is attached at its upper edge to a short, narrow, ridgelike anterior portion. The hinge margin of the left valve bears an anterior tooth and postjacent socket, a narrow bar that extends the length of the hinge line, and a long posterior socket that is narrow anteriorly and suddenly expanded posteriorly, corresponding to the shape of the posterior tooth of the right valve. Below the narrow anterior portion of this socket, there is a small tooth which fits into the notchlike angle formed by the knoblike posterior portion with the ridgelike anterior portion of the posterior tooth of the right valve. In Recent and in later Tertiary species of *Loxoconcha*, the narrow bar of the left valve is distinctly crenulate, and the corresponding furrow of the right valve is finely notched; in Early Tertiary species the bar is faintly crenulate in most species, and in Cretaceous species, smooth. The terminal teeth and sockets are well developed in most Recent and Tertiary species, but are small and obscure in many Cretaceous species; the anterior tooth of the right valve and the corresponding socket of the left valve are especially weakly developed in all the Cretaceous specimens examined by the writer. There seems to be a definite tendency toward increase in the strength of the hinge structure in the genus *Loxoconcha* throughout the Tertiary period. (Pl. 34, figs. 7, 8.)

Line of concrescence is at a moderate distance from the outer margin of the shell at the anterior and posterior ends, and lies much nearer the outer margin along the ventral edge. The inner margin and the line of concrescence coincide or are very close together throughout. Radial pore-canals moderately numerous, slender, straight, simple (Pl. 35, fig. 8).

Muscle scar obscured by surface sculpture.

Genotype, *Cythere impressa* Baird.

LOXOCONCHA PERDECORA Alexander, n. sp.
Plate 33, figure 11; Plate 34, figures 7, 8; Plate 35, figure 8

Carapace in side view quadrate, distinctly elongate, of equal height throughout. Dorsal margin straight. Ventral margin sinuate slightly in front of middle, curving gradually upward posteriorly to the short, blunt caudal process. Anterior end somewhat obliquely rounded, bearing a narrow, compressed border. Surface of valves strongly and finely reticulate; reticular ridges low, broad, rounded. Four small, deep pits are located in a slight depression near the center of the valves, in a position corresponding to the muscle-scar area on the interior of the shell. Carapace strongly convex, widest at middle, slightly tumid and bulging ventrally.

Length of holotype 0.43 mm., height 0.23 mm., width 0.23 mm.

L. perdecora is a rare species, occurring in both the Kincaid and Wills Point clays. Similar species have been observed both in the underlying Cretaceous formations and in the overlying Tertiary of the Gulf Coast region, and *L. perdecora* is undoubtedly a member of a phylogenetic series which can be traced from Upper Cretaceous to Oligocene in this area.

Type locality, station 21.

LOXOCONCHA CORRUGATA Alexander, n. sp.
Plate 33, figure 13

Carapace in side view quadrate, highest near posterior end. Dorsal margin straight. Ventral margin sinuate slightly in front of middle, curving abruptly upward posteriorly to the short, blunt, compressed caudal process. Anterior end obliquely rounded, with narrow, compressed border. Valves strongly convex, widest slightly behind middle. Surface strongly reticulate; pits near center of valves irregularly arranged, those near dorsal and ventral margins in longitudinal rows which curve upward near the ventral and downward near the dorsal margin; ridges between longitudinal rows of pits strongly elevated, forming distinct costae.

Length of holotype 0.43 mm., height 0.24 mm., width 0.12 mm. (single valve).

This species is very rare, and has been collected at but two exposures of Wills Point clays, stations 11 and 21.

Type locality, station 21.

LOXOCONCHA NUDA Alexander, n. sp.
Plate 33, figure 12

Carapace in side view long, slender, quadrangular, highest at anterior end. Dorsal margin straight. Ventral margin sinuate at middle, curving upward very gradually toward the short, blunt caudal process. Anterior end obliquely rounded. Valves moderately convex, widest at middle. Surface smooth, except for two to three low, short, obscure longitudinal plications near the ventral edge of the shell.

Length of holotype 0.42 mm., height 0.22 mm., width 0.18 mm.

L. nuda has been collected from the type locality only, an exposure of the Littig bed of the Kincaid formation at station 22.

LOXOCONCHA PRAVA Alexander, n. sp.
Plate 33, figure 14

Carapace in side view elongate, quadrate, of equal height throughout entire length. Dorsal margin very slightly concave. Ventral margin nearly straight, slightly flexuous, paralleling dorsal margin. Anterior end obliquely rounded. Posterior end low, obliquely rounded, without distinct caudal process. Valves irregularly convex, widest ventrally, near

middle, and at postero-dorsal angle. Surface of valves strongly reticulate; pits deep, angular, ridges broad, flat. Posterior half of ventro-lateral edge of the valves bears a low but distinct ridge, which parallels the curvature of the postero-ventral margin of the shell.

Length of holotype 0.48 mm., height 0.26 mm., width 0.12 mm. (single valve).

L. prava has been found only at the type locality, an exposure of clays at the top of the Wills Point formation, station 8.

Genus KRITHE Brady, Crosskey and Robertson, 1874

Carapace in side view oblong, highest at or slightly posterior to middle. Dorsal margin gently arched. Ventral margin straight or nearly so. Anterior end rounded. Posterior end obliquely truncated, with subacute, rounded, postero-ventral angle. In dorsal view, carapace varies from moderately to strongly convex; anterior end acute to subacute, posterior end blunt, incised at middle. Surface smooth, or rarely obscurely punctate or papillate.

Hinge structure without teeth, consisting of a slight groove in the dorsal margin of the left valve, into which the dorsal edge of the right valve fits.

Line of concrescence extends vertically downward from the dorsal margin, at about one-fifth the length of the shell from the anterior end. In the lower half of the anterior end, it makes a broad, distally expanded loop which approaches very near to the outer margin of the shell, and a similar, narrower loop at the postero-ventral angle of the shell, but elsewhere it runs at a moderate distance from, and parallel to, the outer margin. Inner margin and line of concrescence coincide except where the latter makes its sharp, looplike curves toward the outer margin at the anterior and posterior ends. Radial pore-canals moderately numerous, slender, with large external openings, often curved, and of very unequal length; many of the canals open on the exterior surface of the shell before reaching the outer margin. Normal canals few in number, large, conspicuous.

Muscle-scar pattern consists of a vertical row of four long, slender scars, with two others in front of these; the upper one of these two is large and roughly U-shaped, the lower one small, elongated and narrow, (Pl. 35, fig. 18.)

Sexual dimorphism marked, the shells of the males being longer and more slender, and less strongly convex than those of the females.

Genotype, *Cytherideis bartonensis* Jones.

KRITHE PERATTICA Alexander, n. sp.

Plate 34, figures 1, 2; Plate 35, figure 18

Carapace of female rhomboidal in side view, highest at middle. Dorsal margin rather strongly arched, curving downward posteriorly in a smooth, unbroken curve to the rounded, subacute postero-ventral angle. Ventral margin gently convex downward. Anterior end evenly rounded. Carapace strongly convex, widest at middle.

Carapace of male similar in outline to that of female, but with dorsal margin less strongly arched, ventral margin nearly straight, and with valves less strongly convex.

Length of holotype (female) 0.7 mm., height 0.37 mm., width 0.15 mm. (single valve).

K. perattica has been found at only a few outcrops, and with the exception of a single specimen, all the representatives in the writer's collections are from the Wills Point formation.

Type locality, station 12.

Genus CYTHEROPTERON Sars, 1865

Subgenus CYTHEROPTERON Sars, s. s.

Shell ovate in outline. Dorsal margin arched. Ventral margin straight or more or less strongly convex. Anterior end rounded. Posterior end produced to form a short, blunt, narrow, compressed caudal process which curves more or less strongly upward. Carapace widest at ventral margin. Ventro-lateral edges of valves bear more or less strongly devel-

oped alaeform lateral expansions. Valves subequal in size, the left valve characteristically slightly larger than the right. Surface smooth or with moderate sculpture.

Hinge of right valve consists of two teeth, one at each end of the hinge line, each bearing several cusps with corresponding notched sockets in the left valve. Hinge margin of left valve, between the terminal sockets, bears a finely crenulate bar, which fits into an obscure, notched furrow between the terminal teeth of the right valve.

Line of concrescence at a moderate distance from, and parallel to, the outer margin of the shell. Inner margin and line of concrescence coincide except at the anterior end, where the course of the inner margin is at a slight distance within that of the line of concrescence. Radial pore canals few, straight, simple.

Muscle-scar pattern consists of a vertical row of four small scars, with either one or two others in front of these.

The hinge structure and the marginal zones and radial pore-canals of the genotype *Cytheropteron convexum* Sars, (= *Cytheropteron latissimum* (Norman)), are figured by Alexander in his paper on the shell structure of the genus *Cytheropteron*.[35]

CYTHEROPTERON (CYTHEROPTERON) MIDWAYENSIS Alexander, n. sp.
Plate 33, figure 17

Carapace in side view elongate, ovate, highest in front, tapering rather strongly posteriorly. Dorsal margin moderately arched, nearly straight and sloping rather steeply along hinge line. Anterior end obliquely rounded. Posterior end produced to form short, narrow caudal process. Valves strongly convex, widest and tumid ventrally, but without well developed alaeform expansions. Lateral surface of valves densely and finely punctate, giving shell a finely granular appearance. Ventral surface with four fine, narrow, parallel longitudinal ridges.

Length of holotype 0.62 mm., height 0.35 mm., width 0.54 mm.

This species has been found only at the type locality, in the base of the Wills Point formation, station 8.

CYTHEROPTERON (CYTHEROPTERON) ALIGERUM Alexander, n. sp.
Plate 33, figure 16

Carapace almost perfectly ovate in outline. Dorsal margin gently and evenly arched. Ventral margin convex downward. Anterior end narrow, evenly rounded. Posterior end tapering, produced slightly above middle to form narrow, caudal process. Carapace strongly convex, lateral alaeform expansions strongly produced, tapering distally to form a slender, needle-like spine on each valve; a fine, short spine lies immediately behind the base of the longer one. Surface marked by several low, broad, flat, obscure ridges, which are obliquely disposed, and form a faint reticular pattern.

Length of holotype 0.42 mm., height 0.22 mm., width 0.2 mm. (single valve).

This peculiarly marked species has been collected at the type locality only, an exposure of uppermost Kincaid clays, at station 8.

Genus MONOCERATINA Roth, 1928

Carapace in side view quadrate, distinctly elongate, of nearly equal height throughout. Dorsal margin straight. Ventral margin straight or slightly convex, paralleling the dorsal margin. Anterior end rounded, in some species bearing a marginal rim or flange and marginal denticles or spines. Posterior end more or less strongly tapering, bearing a narrow, compressed caudal process near the postero-dorsal angle. Carapace moderately to strongly convex, in most species widest near the ventral margin. One of the most characteristic features of the genus is the presence of a strong, horn-like spine which in most species lies at or

[35] Alexander, C. I., Shell structure of the ostracode genus *Cytheropteron*, and species from the Cretaceous of Texas: *Jour. Paleontology*, vol. 7, pl. 25, figs. 13*a*, *b*; pl. 26, figs. 1*a*, *b*, 1933.

near the ventral margin and slightly behind the middle. The surface in some species is smooth, in others ornamented with ridges, pits, tubercles, and small spines.

Hinge structure simple, consisting of a narrow bar in the left valve, which fits into a slight groove or furrow in the right valve.

Line of concrescence and inner margin coincide throughout, and their course is near, and parallel to, the outer margin. The radial pore-canals are few, widely spaced, simple, straight, and narrow. The muscle-scar pattern could not be observed in any specimens examined by the writer.

Roth, in his original description of the genus, assigned it to the family Primitiidae, but Alexander has recently made a detailed analysis of the shell structure, demonstrating its affiliation with the family Cytheridae.[36]

Genotype, *Monoceratina ventralis* Roth.

MONOCERATINA SPECIOSA Alexander, n. sp.
Plate 34, figure 6

Carapace elongate, subquadrate in outline, highest at middle. Dorsal margin straight. Ventral margin strongly convex downward, curving upward posteriorly to the caudal process near the postero-dorsal angle. Anterior end evenly rounded, its curvature blending without break into that of the convex ventral margin. Carapace strongly convex, widest at ventral margin. A deep, narrow, median sulcus divides the carapace, including the strongly elevated ventro-lateral edge, into approximately equal lobes. The ventro-lateral edge of the valves, immediately in front of the sulcus, bears a low, broad, rounded tubercle, and immediately behind the sulcus, a short, stout, tapering, hornlike spine. The surface of the anterior lobe, with the exception of a broad, smooth area near the anterior margin, is marked by numerous, flexuous, vertical ridges. The lateral surface of the posterior lobe is smooth. The entire ventro-lateral edge and the ventral surface of the valves are densely beset with fine, short spines, which, on the ventral surface, are arranged in parallel longitudinal rows.

Length of holotype 0.9 mm., height 0.4 mm., width 0.35 mm. (single valve).

M. speciosa has been found at the type locality only, an exposure of Wills Point clays, station 21.

MONOCERATINA ROSSAE Alexander, n. sp.
Plate 34, figure 5

Carapace in side view elongate, quadrate in outline. Dorsal margin straight. Ventral margin straight and parallel to dorsal margin. Anterior end evenly rounded. Posterior end tapering, with short, blunt caudal process. Anterior and posterior ends of carapace compressed, central portion strongly convex, widest near ventral margin. Ventro-lateral edge of valves bears a high, narrow, longitudinal ridge which terminates posteriorly in a stout, laterally projecting spine. A deep, median vertical sulcus divides the valves into two approximately equal lobes. A narrow, rounded ridge arises slightly above the middle of the anterior lobe, and pursues an irregular, flexuous course upward and backward, joining the dorsal margin just in front of the upper end of the vertical sulcus and extending backward from that point along the dorsal margin to the postero-cardinal angle, where it becomes obsolete. Lower surface of anterior lobe bears three low, short, ridges which pursue somewhat irregular courses upward and backward from the ventro-lateral edge. Remainder of lateral surface smooth, glassy. Ventral surface smooth, bearing a high, narrow longitudinal ridge.

Length of holotype 0.65 mm., height 0.3 mm.

This species has been found only at the type locality, an exposure of uppermost beds of the Wills Point formation, station 19.

[36] Alexander, C. I., Shell structure of the ostracode genus *Cytheropteron*, and species from the Cretaceous of Texas: *Jour. Paleontology*, vol. 7, p. 202, 1933.

Genus ORTHONOTACYTHERE Alexander, 1933

Carapace ovate to quadrate. Dorsal margin straight. Ventral margin straight or more or less strongly convex, tending to parallel the dorsal margin in the anterior one-half to three-fourths of its length, curving upward posteriorly to the short, blunt, compressed caudal process at or near the postero-dorsal angle. Carapace moderately to strongly convex, widest and more or less tumid ventrally. Surface tuberculate, and except for tubercles may be smooth, but more commonly bears in addition pits, spines, a mesh-work of fine ridges, or other surface ornamentation.

Hinge structure like that of *Cytheropteron*.

Line of concrescence and inner margin coincide throughout, and are at a moderate distance from, and parallel to, the outer margin. Radial pore-canals few, straight, simple.

The shell structure of the genotype, *O. hannai* (Israelsky) is figured by Alexander with the original generic description.[37]

Genotype, *Cytheridea* (?) *hannai* Israelsky.

ORTHONOTACYTHERE CRISTATA Alexander

Orthonotacythere cristata ALEXANDER, *1934*, Jour. Paleontology, vol. 8, p. 65, pl. 8, fig. 11.

This distinctive and highly ornamented species has been found in both the Kincaid and Wills Point formations, but is rare wherever it has been collected. It is very similar to and obviously derived from *O. hannai* (Israelsky), as pointed out in the original description.

Genus XESTOLEBERIS Sars, 1865

Carapace in side view ovate, highest at or distinctly behind middle. Dorsal margin arched. Ventral margin straight or slightly convex downward. Anterior end low, narrow, rounded or subacutely angled. Posterior end broadly rounded. Valves moderately to strongly convex, carapace widest and roundly tumid posteriorly. Surface smooth, or in some species finely punctate or papillate.

Hinge structure of the right valve consists of a finely denticulate anterior ridge that occupies nearly half the length of the hinge margin, a posterior tooth that bears numerous small cusps, and between the ridge and the tooth, a long, narrow, shallow, notched furrow or groove. The left valve bears a long, narrow, notched anterior groove, a small posterior socket, and an intermediate denticulate ridge or bar (Pl. 34, figs. 9, 10).

Line of concrescence very near, and parallel to, the outer margin of the shell around the entire periphery. Inner margin and line of concrescence coincide except at the anterior end, where the course of the inner margin is at a considerable distance within that of the line of concrescence, but is still roughly parallel to the outer margin, and along the postero-ventral region where the inner margin lies at a slight distance within the line of concrescence. Radial pore-canals numerous, closely spaced, rather large, straight, simple.

Muscle-scar pattern consists of a vertical row of four long, narrow scars, with a single larger, U-shaped scar in front of these (Pl. 35, fig. 7).

Genotype, *Cythere aurantia* Baird.

XESTOLEBERIS TRUNCATA Alexander, n. sp.

Plate 34, figures 3, 4, 9, 10; Plate 35, figure 7

Carapace of female ovate in outline. Dorsal margin strongly arched, highest slightly behind middle, sloping flatly toward each end, with anterior slope slightly steeper than posterior. Ventral margin gently convex downward. Anterior end low, narrow, rounded. Posterior end high, obliquely rounded, continuous with curvature of ventral margin, and meeting the dorsal margin almost at right angles, forming an obscure

[37] Alexander, C. I., Shell structure of the ostracode genus *Cytheropteron*, and species from the Cretaceous of Texas: *Jour. Paleontology*, vol. 7, p. 199, pl. 25, fig. 1, pl. 26, fig. 6, 1933.

postero-dorsal angle. Carapace strongly convex, widest near posterior end; in dorsal view, anterior end subacute, posterior end bluntly rounded.

Carapace of male elongate ovate in side view, highest slightly behind middle. Dorsal margin like that of female, but less strongly arched. Ventral margin straight. Anterior and posterior ends as in female. Carapace moderately convex, widest at middle; in dorsal view anterior end subacute, posterior end somewhat more obtuse, rounded.

Length of holotype, (female), 0.36 mm., height 0.22 mm., width 0.2 mm.

X. truncata has been collected from exposures of both the Kincaid and Wills Point clays, but appears somewhat more frequently in the latter formation.

Type locality, station 21.

DESCRIPTION OF OUTCROPS

Station 1. Deep ditch 0.7 mile by road from the town square in Commerce, Hunt County, Texas, on the Paris highway. The gray to buff, compact clays of Kincaid age carry numerous badly leached large fossils and an abundance of foraminifera and ostracodes. This is the type locality for *Cytheridea ruida* n. sp. (Locality previously described as sta. 3, Texas Univ., Bull. 2644, p. 45, 1927.)

Station 2. Gully in field 3 miles northwest of Campbell, Hunt County. These yellowish and compact clays of the lower part of the Kincaid formation are rich in both foraminifera and ostracodes. (Locality previously described as sta. 3A, Texas. Univ., Bull 2644, p. 45, fig. 7, 1927.)

Station 3. Deep ditch at road fork 1½ miles south of Lone Oak, Hunt County, on the road to Hooker School. This yellowish-gray and somewhat gypsiferous clay of Kincaid age carries some shells, numerous foraminifera and very frequent ostracodes. This is the type locality for *Cytherella turgidula* n. sp. (Locality previously described as sta. 6, Texas Univ., Bull. 2644, p. 46, fig. 8, 1927.)

Station 4. Gully on south side of hill about 4 miles southwest of Lockhart, Caldwell County, business center, and about 1½ miles south of the Wilford-Bochart well. This very compact clay of Kincaid age carries numerous typical foraminifera and ostracodes.

Station 5. Creek bank just north of a small bridge along an east-west road at a point about 3 miles due south of Lone Oak, Hunt County. These typical and somewhat silty clays of the Kincaid formation lie about 50 feet below the glauconitic and phosphatic zone which marks the base of the Wills Point formation in this area. (Locality previously described as sta. 7, Texas Univ., Bull 2644, p. 47, fig. 8, 1927.)

Station 6. Deep ditch 3 miles northwest of Elgin on west side of secondary road leading to Lund, and lying on the Bastrop-Travis county line, about 0.5 mile north of its junction with the Austin-Elgin highway. This yellow, silty, somewhat glauconitic, and well laminated and fossiliferous clay near the top of the Kincaid formation carries an abundance of foraminifera and ostracodes. This is the type locality for *Cytheridea ruginosa* n. sp.

Station 7. Steep bluff on right bank of Colorado River about 1 mile below the Bastrop-Travis county line. The dark, fossiliferous, glauconitic clay at the base of the bank is rich in *Cucullea macrodonta* Whitfield and lies near the top of the Kincaid formation and about 25 feet below the strata exposed at station 8. Foraminifera and ostracodes are numerous, and this has been selected as the type locality for *Brachycythere plena* n. sp., *B. interrasilis* n. sp., *Cythereis midwayensis* n. sp. and *Cytheromorpha scrobiculata* n. sp.

Station 8. Right bank of Colorado River on Caldwell Ranch, about 1,000 feet below the mouth of Dry Creek. These fossiliferous strata below the true *Vernericardia bulla* bed lie at the top of the Kincaid formation and carry numerous foraminifera and ostracodes. About 200 feet downstream, south of a small

fault, basal beds of the Wills Point formation, above the *V. bulla* bed are exposed. The upper Kincaid strata at this exposure constitute the type locality for *Loxoconcha prava* n. sp., and *Cytheropteron aligerum n. sp.* The basal Wills Point beds have been selected as the type locality for *Cytheropteron midwayensis* n. sp. (Locality previously described as sta. 214, U. S. Geol. Survey, Prof. Paper 126, fig. 11, 1924.)

Station 9. About 5¾ miles in a direct line north by west of Lockhart, Caldwell County, along a small creek bank about one-half mile west of the Austin-Lockhart road typical yellowish-grey clays crop out in several slopes just below a fossiliferous zone rich in the casts of *Hercoglossa* sp. These clays constitute the type locality for *Cythereis cancellosa* n. sp.

Station 10. Shallow ditch nearly 3 miles south by east of Lone Oak, Hunt County. The glauconitic clays of this exposure carry phosphate nodules and an abundance of foraminifera and ostracodes. (Locality previously described as sta. 8, Texas Univ., Bull. 2644, p. 47, fig. 8, 1927.)

Station 11. Deep ditch along Austin-Lockhart highway, 1.5 miles by road north of the M. K. and T. railroad station in Lockhart, Caldwell County, on the north slope of a tributary to Plum Creek. This sticky, compact, slightly yellowish clay lies in the Mexia clay member of the Wills Point formation. It is rich in typical and well-preserved foraminifera and ostracodes.

Station 12. Exposure in field about 2 miles east-north-east of Honest Ridge School southwest of Mexia, Limestone County, about three-quarters of a mile south of Big Williams well, and approximately 3½ miles north of Groesbeck. These very compact, massive, somewhat yellowish-gray clays of the Mexia clay member of the Wills Point formation wash to a concentrate composed almost wholly of well preserved foraminifera and ostracodes. This is the type locality for *Krithe perattica* n. sp.

Station 13. Roadside ditch about 2½ miles in a direct line northwest of the M. K. and T. railroad station in Lockhart, Caldwell County, and at a corner about three-quarters of a mile west of the Sun-Cardwell No. 1. This compact, yellowish-gray clay of the Mexia clay member of the Wills Point formation is rich in typical foraminifera and ostracodes.

Station 14. Exposure in side of a hill about 4 miles in a direct line west-southwest of Lockhart, Caldwell County, business center, south of Dry Branch about one-half mile west of its junction with Clear Fork, and about one-quarter of a mile north of station 4. This compact yellowish-gray clay of the Mexia clay member of the Wills Point formation is rich in typical foraminifera and ostracodes.

Station 15. Gully about 2 miles in a direct line north-northwest of the M. K. and T. railroad station in Lockhart, Caldwell County, and about 2,000 feet west of the Sun-Cardwell No. 1, and

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EXPLANATION OF PLATE 34

FIGS. 1, 2—*Krithe perattica* Alexander, n. sp.; 1, female, lateral view, left valve; 2, male, lateral view, left valve; both figures ×60. (p. 229)

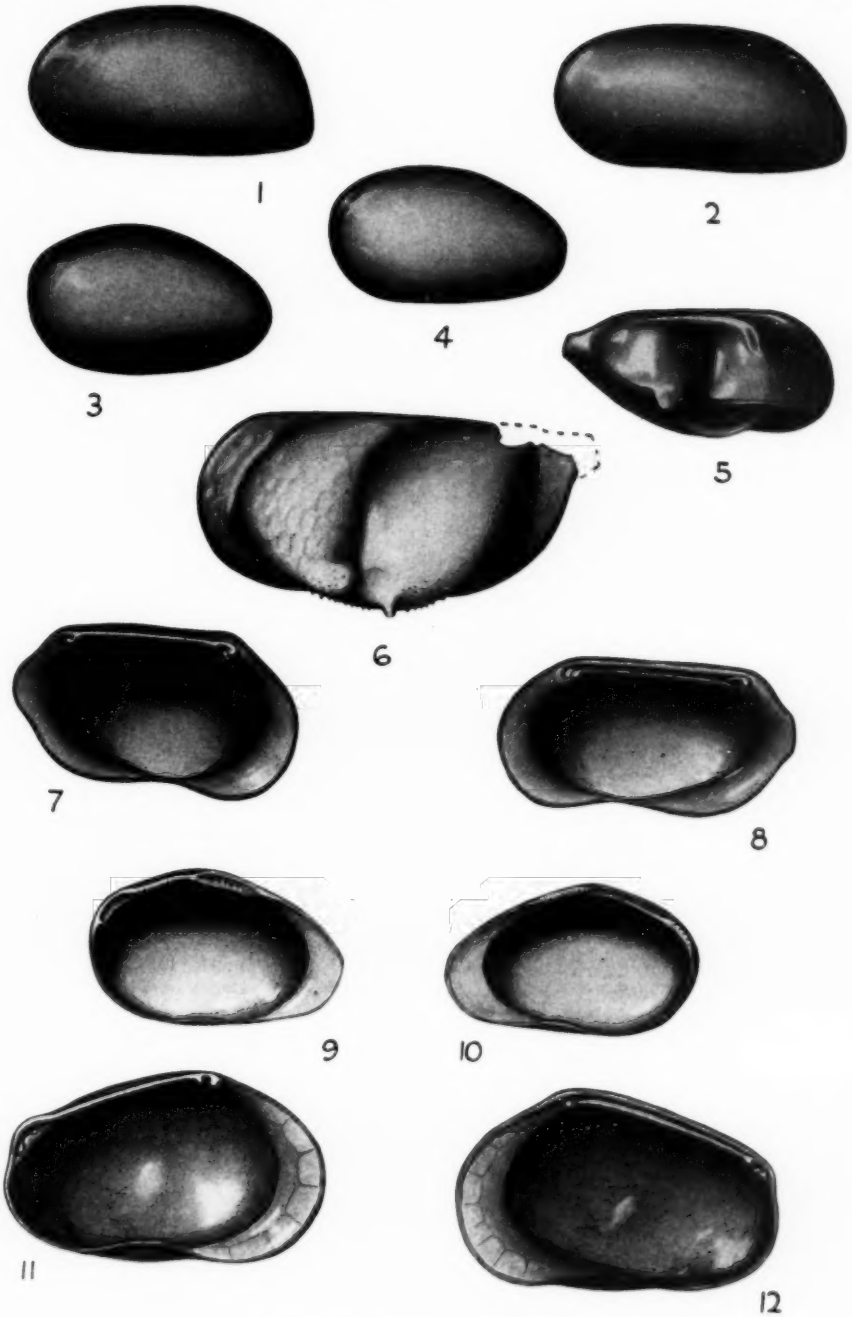
3, 4, 9, 10—*Xestoleberis truncata* Alexander, n. sp.; 3, female, right valve view; 4, male, right valve view; 9, interior of left valve; 10, interior of right valve; all figures ×95. (p. 232)

5—*Monoceratina rossae* Alexander, n. sp.; lateral view, right valve, ×60. (p. 231)

6—*Monoceratina speciosa* Alexander, n. sp.; lateral view, left valve, ×60. (p. 231)

7, 8—*Loxoconcha perdecora* Alexander, n. sp.; 7, interior of left valve; 8, interior of right valve, ×95. (p. 228)

11, 12—*Cytheromorpha fuscata* (Brady); 11, interior of left valve; 12, interior of right valve; both figures ×80. (p. 223)



Alexander, Eocene ostracodes

somewhat less than a quarter of a mile southwest of Plum Creek. This compact and somewhat yellowish clay of the Mexia clay member of the Wills Point formation is rich in typical foraminifera and ostracodes.

Station 16. Roadside bank and tributary exposure about 3 miles in a direct line north by west of the M. K. and T. railroad station in Lockhart, Caldwell County, and along a secondary road to Elm Creek School. These excellently exposed clays of the Mexia clay member of the Wills Point formation carry a fairly rich microfauna.

Station 17. Ditch at road intersection about 2¾ miles due east of the center of Lockhart, Caldwell County, and about three-quarters of a mile south of Blanks. This loose, yellowish, silty clay of Wills Point age carries an abundance of typical foraminifera and frequent ostracodes.

Station 18. About 2 miles in a direct line northeast of Lone Oak, Hunt County, in a stream bank just west of the road, and about 1 mile due west of the Corley No. 1. This very tough and compact clay of the Mexia clay member of the Wills Point formation carries a wealth of fresh foraminifera and ostracodes.

Station 19. South bank of Foggyhead Creek in Smith's pasture about 0.15 mile west of the bridge on the Kerens-Round-Prairie road, 3.8 miles by road south-southeast of the railroad station in Ker-

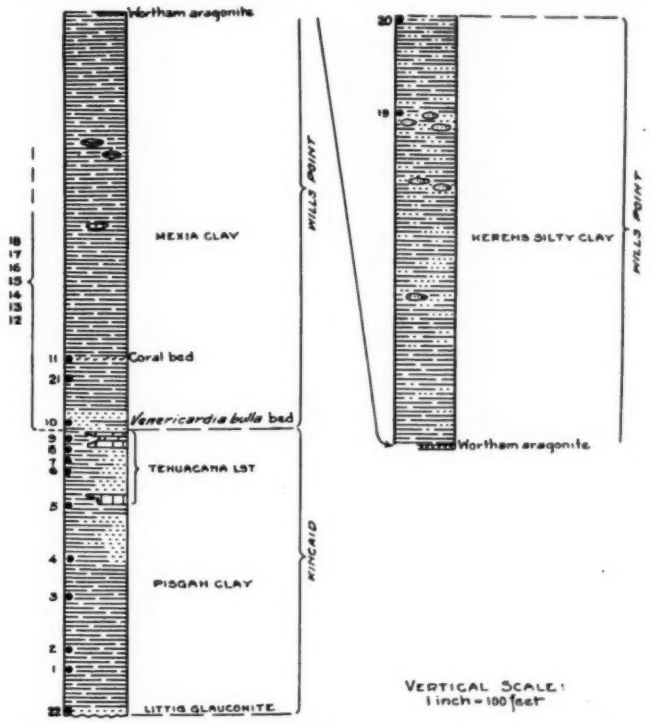


FIG. 1.—Generalized columnar section of the Midway group of strata in central and east-central Texas, showing the divisions of the Kincaid and Wills Point formations and the stratigraphic succession of outcrops (dots and station numbers) used in this report. The outcrops 12 to 18 occur either as too isolated or in such badly faulted areas, that it is impossible to arrange them stratigraphically with any degree of certainty, but it is certain that they lie within the Mexia clay member and probably in its lower part.

ens, Navarro County. These somewhat fossiliferous, silty and micaceous clays carry the foraminiferal fauna typical of the uppermost strata of the Wills Point formation, characterized especially by *Ammobaculites midwayensis* Plummer and *A. expansus* Plummer. Ostracodes are frequent, and the holotype of *Monoceratina rossae* n. sp. has been taken from this material. (This locality previously described as Sta. 174-T-6, Texas Univ., Bull. 3201, p. 62, 1932.)

Station 20. Excavation made for foundation for new bridge over Guadalupe River 3 miles southwest of Seguin, Guadalupe County. During the construction of the bridge the topmost strata of the Wills Point formation were well exposed just below the contact with the overlying Wilcox sands, which were also exposed during the construction. The Wills Point silty clays are typical of uppermost strata of this formation, and ostracodes are frequent and well preserved.

Station 21. Steep bank along east side of tributary running due north into Tehuacana Creek, about 2 miles in a direct line north and slightly west of the center of the town of Mexia, Limestone County, and one-quarter of a mile west of the railroad. The very compact, gray, fossiliferous clays carrying numerous small corals lies within the Mexia clay member of the Wills Point formation and about 35 feet above the top ledge of the Tehuacana limestone. A few yards north and west of this outcrop along the creek, lignitic Wilcox strata are faulted down against these lower strata of the Wills Point formation. This is the type locality for *Cytherella tumidosa* n. sp., *C. excavata* n. sp., *C. symmetrica* n. sp., *Argilloecia faba* n. sp., *Paracypris perapiculata* n. sp., *Bairdia suborbiculata* n. sp., *Brachycythere formosa* n. sp., *Cythereis sculptilis* n. sp., *C. lemnicata* n. sp., and *Eucythere midwayensis* n. sp. Plesiotypes of *Cythereis spiniferrima* Jones and Sherborn and *C. prestwichiana* Jones and Sherborn have been figured from these clays.

Station 22. Shallow gully in a field 200 feet north of the Lone Oak-Greenville highway, about 3 miles northwest of Lone Oak, Hunt County. The Navarro-Kincaid contact is exposed here, and the Navarro strata constitute the type locality for *Cythereis huntensis* (Alexander) and *Cytheridea macropora* Alexander. The glauconitic, basal Kincaid strata are now made the type locality for *Argilloecia subcylindrica* n. sp., *Brachycythere foraminosa* n. sp., *Cytheridea fornicata* n. sp., and *Loxoconcha nuda* n. sp.

EXPLANATION OF PLATE 35

FIGS. 1, 2—*Cytherella turgidula* Alexander, n. sp.; 1, dorsal view of female; 2, dorsal view of male; both figures ×40. (p. 210)

3, 4—*Cytherella tumidosa* Alexander, n. sp.; 3, dorsal view of female; 4, dorsal view of male; both figures ×40. (p. 209)

5, 6—*Cytherella excavata* Alexander, n. sp.; 5, dorsal view of female; 6, dorsal view of male; both figures ×40. (p. 211)

7—*Xestoleberis truncata* Alexander, n. sp.; right valve by transmitted light, showing inner margin, line of concrescence and radial pore-canals; ×95. (p. 232)

8—*Loxoconcha perdecora* Alexander, n. sp.; left valve by transmitted light, showing inner margin, line of concrescence and radial pore-canals; ×95. (p. 228)

9, 15—*Paracypris perapiculata* Alexander, n. sp.; 9, left valve by transmitted light, showing inner margin (partially destroyed), line of concrescence and radial pore-canals, ×80; 15, dorsal view of holotype, ×40. (p. 214)

10, 11—*Cythereis* (*Pterygocythereis*) *lemnicata* Alexander, n. sp.; 10, muscle-scar, right valve by transmitted light, ×160; 11, dorsal view of left valve, ×40. (p. 222)

12, 14—*Argilloecia faba* Alexander, n. sp.; 12, dorsal view, ×95; 14, left valve by transmitted light, showing inner margin (reconstructed), line of concrescence, radial pore-canals, and muscle scars, ×250. (p. 213)

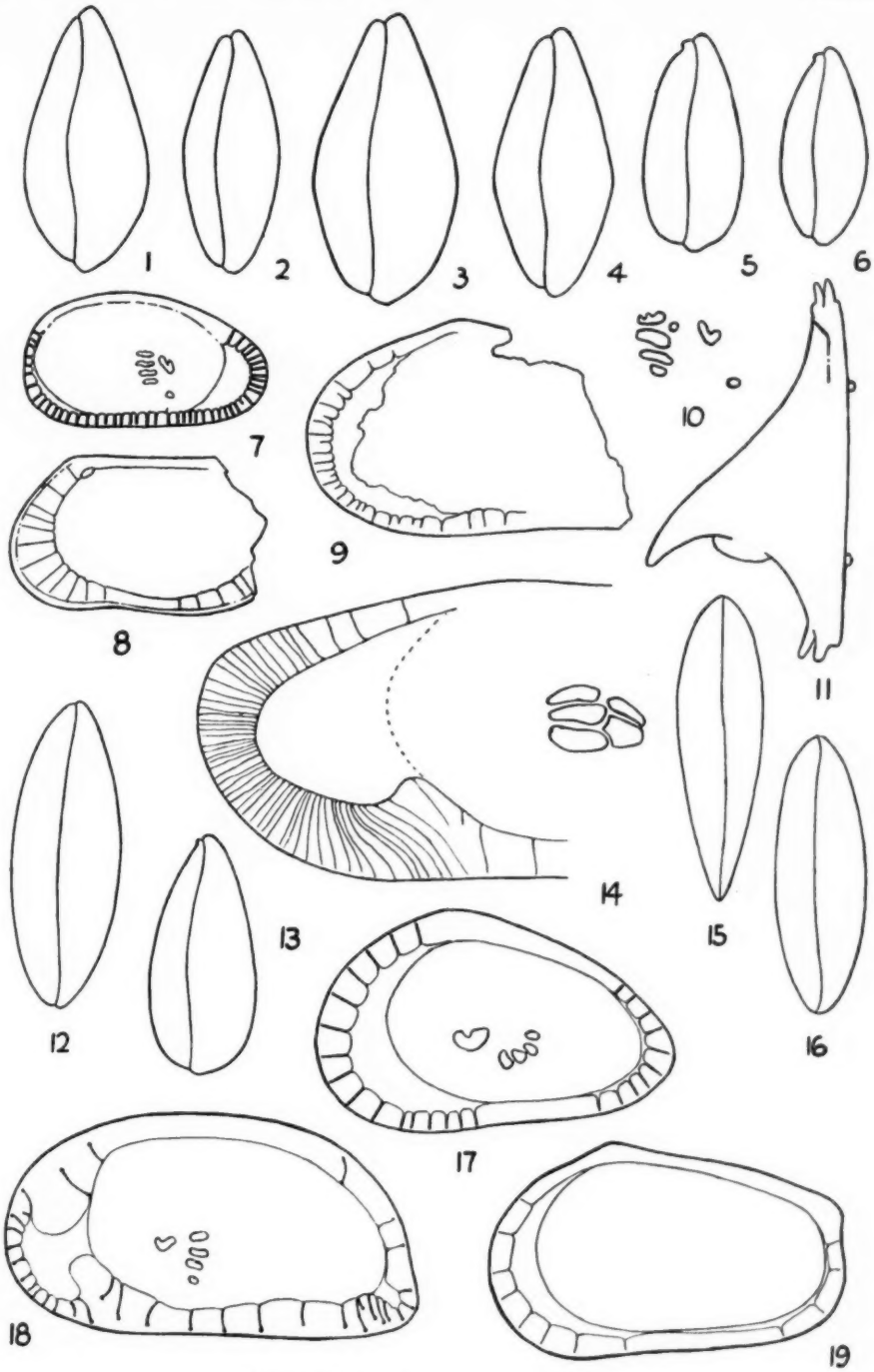
13—*Cytherella symmetrica* Alexander, n. sp.; dorsal view of female, ×40. (p. 212)

16—*Argilloecia subcylindrica* Alexander, n. sp.; dorsal view, ×95. (p. 214)

17—*Eucythere declivis* (Norman); left valve by transmitted light showing inner margin, line of concrescence, radial pore-canals and muscle scars, ×90 (after G. W. Müller). (p. 227)

18—*Krithe perattica* Alexander, n. sp.; left valve by transmitted light, showing inner margin, line of concrescence, pore-canals and muscle scars, ×80. (p. 229)

19—*Cytheromorpha fuscata* (Brady); left valve by transmitted light, showing inner margin, line of concrescence and radial pore-canals, ×80. (p. 223)



Alexander, Eocene ostracodes

SUPPLEMENT TO BIBLIOGRAPHY AND INDEX TO GENERA AND SPECIES OF FORAMINIFERA FOR THE YEAR 1931

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The first annual Bibliography and Index to new genera and species of Foraminifera, which appeared in vol. 7 (1933) of this *Journal* (pp. 343–355), was compiled by me while engaged as a micro-palaeontologist in the Dutch East Indies. The impossibility of consulting larger libraries in tropical countries, as well as the fact that many papers of scientific societies and institutions are often issued after the calendar year has long since past, makes it necessary to publish a supplement to the mentioned Bibliography and Index.

The publications Nos. 1 to 145 inclusive for the year 1931 are listed in vol. 7, pp. 343–349, of this *Journal*. In the following appendix Nos. 146 to 199 inclusive are given, as well as the new genera, species and varieties contained in them.

I am indebted to Dr. J. A. Cushman for the lists of new forms recorded in the papers by Dolgopolskaja and Pauli and Wiesner.

The numbers in bold-face type following the name of the authors in the Index of new species refer to the preceding supplemental Bibliography, and, in some cases, to that already published in vol. 7.

It seems advisable in future to publish jointly both the Bibliography and the Index for the same calendar year.

1. SUPPLEMENT TO THE BIBLIOGRAPHY OF FORAMINIFERA FOR THE YEAR 1931

146. BESAIRIE, H., Sur la stratigraphie des formations sédimentaires de la province d'Analalava (nord-ouest de Madagascar): *C.-R. hébdom. Séances Acad. Sci. Paris*, vol. 193, pp. 868–870.

147. BRADLEY, W. H., Origin and microfossils of the oil shale of the Green River formation of Colorado and Utah: *U. S. Geol. Survey, Prof. Paper* 168, 55 pp., 5 text figs., 28 pls.

148. BRANSON, C. C., New paleontological evidence on the age of the metamorphic series in northeastern Washington: *Science*, new ser., vol. 74, p. 70.

149. BRIGHENTI, D., Sopra una nuova specie di *Trochammina* della valli salse delle Mesola (Nota preliminare): *Bollet. Zool. Napoli. Pubbl. dell'Unione Zool. Ital.*, vol. 2, pp. 13–17, 1 text fig.

150. BROWN, C. B., The geology of northeastern British Somaliland: *Geol. Soc. London, Quart. Jour.*, vol. 87, pp. 259–280, pl. 3, 2 sections, 1 map, 4 figs.

151. BURT, F. A., Glauconite and foraminiferal shells: *Science*, new ser., vol. 74, pp. 457–458.

152. CARTER, C. S., Additions to the list of fossil micro-fauna of the white chalk of Lincolnshire: *Trans. Lincoln. Nat. Union*, 1930, Louth 1931, pp. 175–176 (non vidi).

153. DEECKE, W., Die Invertebraten der Juraformation. (Foraminifera: pp. 10–16). *Oberrhein. Fossilkatalog*, vol. 3, Berlin (Borntraeger).

154. DERVILLE, HENRY, Les Marbres du Calcaire carbonifère en Bas-Boulonnais, Strasbourg, 322 pp., 30 figs., 24 pls.

155. DOLGOPOLSKAJA, M., and PAULI, W., On the Foraminifera of the Black Sea near the Biological Station Karadagh: *Trav. Stat., Biol. Karadagh*, vol. 4, pp. 23–47, 5 text figs., pls. 1–3.

156. DUNN, P. H., The Foraminifera of the Bainbridge (Silurian): (Abstract) *Ohio Jour. Sci.*, vol. 31, p. 279.

157. EHRENBERG, K., Die Palaeontologischen Sammlungen des Palaeontologischen

und Palaeobiologischen Institutes der Universität Wien. 2. Mitteilung: Die Darstellung der Fossilisation: *Palaeobiologica*, vol. 4, pp. 356–396, 1 text fig.

158. Es, L. J. C. van, The age of Pithecanthropus, The Hague (Nijhoff), 142 pp., 11 maps, 4 pls.
159. Fabiani, R., Guida sommaria delle escursioni in occasione del I cinquantenario e del XLIV Congresso della Societa Geologica Italiana, Palermo, in 16°, 8 text figs. (non vidi).
160. Fichter, H. J., Verteilung der Mikrofauna im helvetischen Malmkalk (Quintnerkalk) am Gonzen bei Sargans: *Eclog. Geol. Helv.*, vol. 24, pp. 222–225.
161. Franke, A., Die Foraminiferen eines Paläozängeschiebes von Köthen in Anhalt: *Zeitschr. f. Geschiebeforschg.*, vol. 7, no. 1, pp. 37–40.
162. Franke, A., Uber Mikrofossilien, ihren Bau, ihr Vorkommen und ihre Bedeutung im Haushalt der Natur und in der praktischen Geologie: *Jahrb. Akad. gemeinnütz. Wiss., Erfurt, N.F.*, vol. 50, pp. 64–66.
163. Frenguelli, T., Observaciones estratigraficas en Bahia Sanguinetti (Santa Cruz): *An. Soc. Sci. Santa Fé*, vol. 3, pp. 237–283 (non vidi).
164. Friedel, K., Zur Tektonik der Flyschzone des östlichen Wienerwaldes: *Mitt. Geol. Ges. Wien.*, vol. 31.
165. Gerth, H., Der geologische Bau Javas: *Geol. Rundschau*, vol. 22, pp. 188–200, 3 figs., 2 tables.
166. Gerth, H., Neue Vorkommen von marinem Obercarbon in den nördlichen Anden (Beiträge zur Kenntnis des Carbons in Südamerika von H. Gerth und R. Kräusel. I): *Neues Jahrb. f. Min. etc.*, Beil.-Bd. 65, Abt. B., pp. 521–529, pl. 22.
167. Grahle, Hans-Olaf, Schollen und Geschiebe des Tertiärs in Kiel-Nord: *Zeitschr. f. Geschiebeforschg.*, Bd, 7, Heft 4, pp. 173–181, 3 text figs.
168. Henbest, L. G., The use of selective stains in paleontology: *Jour. Paleontology*, vol. 5, pp. 355–364.
169. Howell, B. F., Study of the oldest Foraminifera: *Nat. Research Council Ann. Rept. Div. Geol. and Geog.*, Appendix E, Subcommittee on Micropaleontology, pp. 6–7.
170. Ihering, H. von, Land-bridges across the Atlantic and Pacific oceans during the Kainozoic era: *Geol. Soc. London, Quart. Jour.*, vol. 87, pp. 376–391.
171. Jenkins, Olaf P., Stratigraphic significance of the Kreyenhagen shale of California: *Mining in California*, pp. 141–186, 10 text figs., 1 pl. (sections) April 1931.
172. Joleaud, L., Les récents progrès de nos connaissances sur l'histoire du Pacifique aux temps tertiaires et la théorie de Wegener: *C.-R. Acad. Sci. Paris*, vol. 192, pp. 628–629.
173. Joleaud, L., L'histoire paléogéographique de l'Océan Pacifique. *C.-R. séances Soc. de Biogéogr.*, vol. 7, no. 62, pp. 9–12.
174. Kahler, Fr., Untersuchungen an Fusuliniden des Karnischen Oberkarbons: *Anzeiger Akad. Wiss. Wien*, vol. 68, pp. 215–216.
175. Kockel, C. W., Richter, M., and Steinmann, H. G., Geologie der Bayerischen Berge zwischen Lech und Loisach: *Wiss. Veröffentl. Deutsch. unt Osterreich. Alpen-Ver.*, vol. 10, Innsbruck.
176. Ktenas, Const. A., and Renz, Carl, Neue Fossilfunde auf der Insel Chios: *Praktika de l'Acad. d'Athene*, vol. 6, pp. 343–347.
177. Kudo, R. A., Handbook of Protozoology, Springfield, Mass., (C. C. Thomas).
178. Leicher, J., Zur Tektonik der Stramberger Tithonklippen: *Lotos, Prag*, vol. 79, pp. 59–93, 4 pls.
179. Marine Biological Association, Plymouth marine fauna: The list of species: Phylum Protozoa: *Plymouth Marine Fauna*, 2d ed., pp. 25–58 (non vidi).
180. Matejka, Al., and Andrusov, D., Aperçu de la Géologie des Carpathes Occidentales de la Slovaquie Centrale et des Régions avoisinantes: *Guide d. Excurs. dans les Carpathes Occid., Knih. Stat. Geol. Ustavu Čskl. Rep.*, vol. 13 A, Prag.
181. Meffert, B., Note on the fauna of the Charkov stage in certain regions of the

S. Russian Paleogene: *Bull. Geol. Prospecting Service, U.S.S.R.*, Leningrad, vol. 50, fasc. 74, pp. 1149–1156. (Russian with English summary).

182. MEFFERT, B., La Faune Éocène du Daralaghez en Arménie: *Trans. Geol. and Prospecting Service, U.S.S.R.*, fasc. 99, pp. 1–64, 4 pls. (Russian with French and English summary.)
183. MIGLIORINI, CARLO I., and DESIO, A., Il Carbonifero dell' Isola di Rodi (Egeo): *Bollet. Soc. Geol. Ital.*, vol. 49 (1930), fasc. 2., pp. 345–354, 4 text figs., Roma, 1931.
184. N. N., De Orbitolinis: *Sc. Nuntis Radiophonicus, Citta del Vaticano*, no. 7, pp. 11–12.
185. OTUKA, YANOSUKE, On the Oiso beds: *Jour. Geol. Soc. Tokyo*, vol. 38, pp. 174–184 (in Japanese).
186. PARONA, CARLO FABRIZIO, Le spugne della Fauna Permiana di Palazzo Adriano (Bacino del Sosio) in Sicilia: *Mem. Soc. Geol. Ital.*, vol. 1, pp. 1–58, pls. 1–12, Roma (non vidi).
187. PING, C., Preliminary notes on the fauna of Nanking: *Contr. Biol. Lab. Sci. Soc. China*, Nanking, vol. 7, pp. 173–201 (non vidi).
188. RAND, WILLIAM W., Preliminary report of the geology of Santa Cruz Island, Santa Barbara County, California: *Mining in California*, pp. 214–219, 1 map, April, 1931.
189. REED, F. COWPER, Upper Carboniferous fossils from Afghanistan: *Pal. Indica*, n.s., vol. 19, pp. 1–39, pls. 1–4.
190. SOLOMONICA, P., Zur tektonischen Stellung der Kieselkalkzone zwischen Wien und Altenmark a.d. Triesting: *Anzeiger Akad. Wiss. Wien.*, no. 16, July 2. 1931.
191. SUZUKI, TASUO, Explanatory text of the Geological Map of Japan: Kochi Sheet. Scale 1:75,000. (Japanese with abstract in English): *Imp. Geol. Survey of Japan.*
192. TAN, KEINOSUKE, On the stratigraphy of the Sanshikyaku District near Taihoku: *Mem. Fac. Sci. Agricult., Taihoku Imp. Univ. Formosa*, vol. 3, no. 3, pp. 199–214, 2 pls., 1 map.
193. THORP, E. M., Descriptions of deep-sea bottom samples from the Western North Atlantic and the Caribbean Sea: *Scripps Inst. Oceanography, Bull., Tech. Ser.*, vol. 3, no. 1, pp. 1–31, 5 text figs., 1 map.
194. VASSOEVICH, N. B., On the parallelism of the Eocene (sensu lato) deposits of Kabristan and of the northern Allochtone of Kachetia (In Russian): *Bull. Unit. Geol. Prospecting Service, U.S.S.R.*, vol. 50, pp. 321–324 (non vidi).
195. VISSER, CHR. K., Boeton-Asphalt: *Asphalt und Teer, Strassenbautechnik*, vol. 31, pp. 831–833, 7 text figs.
196. VOIGT, E., Faziestudien in der Baltischen Kreide auf Grund neuerer Untersuchungen an Geschieben: *Zeitschr. f. Geschiebeforschg.*, vol. 7, pp. 49–86, 2 pls.
197. WELTER, O. A., Apuntas sobre la geologia de los Cerros de Illescas: *Bol. Soc. Geol. Peru*, vol. 4, pp. 25–27, Lima.
198. WESTHEIMER, JEROME M., Classification of Fusulinids: *Micropaleontology Bull.*, vol. 3, no. 1, pp. 7–9, Ann Arbor, Mich.
199. WIESNER, HANS, Die Foraminiferen der Deutschen Südpolar-Expedition 1901–1903: *Deutsche Südpolar-Exped.*, vol. 20, Zool., pp. 53–165, pls. 1–24, Oct., 1931.

2. SUPPLEMENT TO THE INDEX TO GENERA AND SPECIES OF FORAMINIFERA ERECTED DURING THE YEAR 1931

Ammomarginulina nov. gen. Wiesner, **199,** 97, (Genotype: *A. ensis* Wiesner 1931). Recent, Antarctic.

——— *ensis* Wiesner, **199,** 97, pl. 12, f. 147. Recent, Antarctic.

Anomalina plana Wiesner, **199,** 135, pl. 22, f. 267. Recent, Antarctic.

Astrammina nov. gen. Rhumbler in Wiesner, **199,** 77. (Genotype: *A. rara* Rhumbler 1931.) Recent, Antarctic.

——— *rara* Rhumbler in Wiesner, **199,** 78, pl. 2, f. 19. Recent, Antarctic.

Astrorhiza granulosa (Brady 1879) forma *rudis* Rhumbler in Wiesner, **199,** 76, pl. 2, f. 13. Recent, Antarctic.

Biloculina denticulata (Brady 1884) var. *edentata* Wiesner, **199,** 109 (for *B. denticulata* Cushman, 1921, Foram. Phillipine and Adjacent Seas, p. 476, pl. 98, f. 3). Recent, Antarctic.

——— *lata* Wiesner, **199,** 109, pl. 16, f. 189, 190. Recent, Antarctic.

Biloculinella nov. gen. Wiesner, **199,** 69, 110. (Genotype: *Biloculina labiata* Schlumberger 1891.) Recent.

Buliminella elegantissima (d'Orbigny 1839) var. *cochlea* Wiesner, **199,** 124, pl. 19, f. 237. Recent, Antarctic.

Clavulina trilatera Cushman 1926 var. *concava* Cushman, **42** (see Jour. Paleontology, 7, p. 345), 302, pl. 34, f. 12. Upper Cretaceous, Texas.

Cornuspira antarctica Rhumbler in Wiesner, **199,** 101, pl. 14, f. 164–166. Recent, Antarctic.

Cristellaria flinti Wiesner, **199,** 114 (for *C. compressa* Flint 1897 (1899) pro parte, Rept. U. S. Nat. Mus., p. 315, pl. 62, f. 1). Recent.

——— *nummulinaformis* Meffert, **181,** p. 1149, Charkov stage, Paleogene, Southern Russia (region of Mandrilowka).

Cyclammina orbicularis Brady 1881 var. *asellina* Rhumbler in Wiesner, **199,** 97, pl. 13, f. 150 (for *C. orbicularis* Brady, 1884, Chall., pl. 37, f. 19). Recent.

Delosina nov. gen. Wiesner, **199,** 123. (Genotype: *Polymorphina ? complexa* Sidebottom 1907.) Recent.

Discocyclina sella (d'Archiac 1848) var. *electa* Renngarten, **119** (see Jour. Paleontology, vol. 7. p. 348), 23, pl. 3, f. 5, 6. Eocene, Lutetian, Southern Caucasus.

——— *rossica* Meffert, **181,** p. 1149 ff. Charkov stage, Paleogene, Southern Russia. (Region of Mandrilowka.)

——— *umbo* (Schafhäutl 1846) var. *minor* Meffert, **182,** 28, pl. 6, f. 2. Eocene, Auversian, Armenia.

Discorbis vilardeboana (d'Orbigny 1839) var. *karadagica* Dolgopolskaja and Pauli, **155,** 40, pl. 2, f. 8, 9. Recent, Black Sea.

Discospirininae new family Wiesner, **199.**

Ellipsolagena cor Wiesner, **199,** 127, pl. 24, stereo-fig. m-o. Recent, Antarctic.

——— *dorbignyana* Wiesner, **199,** 127, pl. 24, stereo-fig. p. Recent, Antarctic.

——— *fusiformis,* Wiesner, **199,** 126, pl. 24, stereo-fig. j. Recent, Antarctic.

——— *inversa* Wiesner, **199,** 127, pl. 20, f. 246, 247. Recent, Antarctic.

——— *lata* Wiesner, **199,** 126, pl. 24, stereo-fig. k, 1. Recent, Antarctic.

——— *marginata* Wiesner, **199,** 126, pl. 20, f. 245, Recent, Antarctic.

——— *ovata* Wiesner, **199,** 126, pl. 20, f. 244. Recent, Antarctic.

Elphidium (*Polystomella*) *advenum* (Cushman 1922) var. *pontica* Dolgopolskaja and Pauli, **155,** 36, pl. 3, f. 14. Recent, Black Sea.

Entosolenia, see *Lagena.*

Gaudryina gracilis Cushman and Laiming, **45** (see Jour. Paleontology, vol. 7, p. 345), 95, pl. 10, f. 1. Miocene, California.

Globigerina bradyi Wiesner, **199,** p. 133 (for *Globigerina* sp. Brady 1884, Challenger, p. 603, pl. 82, f. 8, 9). Recent.

Granulosphaera nov. gen. Derville, **154,** 131–140 (for *Calcisphaera* Williamson 1854 pro parte. Genotype: *Calcisphaera laevis* Williamson, 1854), pl. 18, f. 71, 73, 74, 75, 78. Seminula-limestone, Carboniferous, France.

Haplophragmoides anomalinoides Rhumbler in Wiesner, **199,** 95, pl. 12, f. 138. Recent, Antarctic.

——— *canariensis* (d'Orbigny 1839) var. *inhaerens* Wiesner, **199,** 95, pl. 12, f. 137. Recent, Antarctic. (For *Truncatulina lobatula* (Walker and Jacob 1792) var. *arenacea* Heron-Allen and Earland 1922.)

——— *sphaeriloculum* (Cushman 1910) var. *lapidigera* Wiesner, **199,** 96, pl. 12, f. 143. Recent, Antarctic. (Note: Cushman's specific name is spelled *sphaeriloculatum.*)

Heterostegina sp. (A-form) Meffert, **182,** 7, text f. 2. Eocene, Upper Lutetian, Armenia.

Hormosina lapidigera Rhumbler in Wiesner, **199,** 92, pl. 10, f. 122–124. Recent, Antarctic.

Hospitellum manumissum Rhumbler in Wiesner, **199,** 89, pl. 8, f. 98. Recent, Antarctic.

Keramosphaerinae subfam. nov. Wiesner, **199,** new subfamily of Neusinidae Cushman 1910.

Lagena gracilis (Williamson 1848) var. *meridionalis* Wiesner, **199,** 117, pl. 18, f. 211. Recent, Antarctic. (For *Lagena gracilis* Brady 1884, pro parte, Challenger, p. 464, pl. 58, f. 19).

——— *pannosa* Millett 1901 var. *simplex* Wiesner, **199,** 118. Recent. (For *L. pannosa* Millett var., 1901, Jour. R. Micr. Soc., pl. 1, f. 14).

——— *squamosa* (Montagu 1803) var. *ocellata* Wiesner, **199,** 118. Recent, Antarctic.

——— *striata* (d'Orbigny 1839) var. *interrupta* Wiesner, **199,** pl. 18, f. 213. Recent, Antarctic.

Lagena (*Entosolenia*) *cellulata* Wiesner, **199,** 121, pl. 19, f. 228, 229. Recent, Antarctic.

——— ——— *cushmani* Wiesner, **199,** 121, pl. 19, f. 225. Recent, Antarctic.

——— ——— *gaussi* Wiesner, **199,** 121, pl. 19, f. 227. Recent, Antarctic.

——— ——— *globosa* (Montagu 1803) var. *caudigera* Wiesner, **199,** 119, pl. 18, f. 214.

——— ——— *marginata* (Walker and Boys 1784) var. *carinata* Wiesner, **199,** p. 121 (for *L. marginata* Brady pro parte, 1884, Challenger, p. 476, pl. 59, f. 23). Recent.

——— ——— *marginata* (Walker and Boys 1784) var. *ventricosa* Wiesner, **199,** 120, pl. 19, f. 222. Recent, Antarctic.

——— ——— *nodosa* Wiesner, **199,** 122, pl. 19, f. 231. Recent, Antarctic.

——— ——— *ovata* (author?) var. *caudigera* Wiesner, **199,** 119, pl. 18, f. 215. Recent, Antarctic. (Note: So far as I am aware there is no species described under the specific designation "*ovata.*")*

——— ——— *quadricostulata* Reuss 1870 var. *parallela* Wiesner, **199,** 122. Recent, Antarctic.

——— ——— *scalariforme-sulcata* Wiesner, **199,** 120, pl. 18, f. 219. Recent, Antarctic.

——— ——— *semiopaca* Wiesner, **199,** 120, pl. 19, f. 223. Recent, Antarctic.

——— ——— *subcostulata* Wiesner, **199,** 120, pl. 18, f. 221. Recent, Antarctic.

——— ——— *texta* Wiesner, **199,** 121, pl. 19, f. 230. Recent, Antarctic.

Miliolina costifera (Terquem 1878) var. *crucioralis* Wiesner, **199,** 105, pl. 15, f. 174. Recent, Antarctic.

——— *planciana* (d'Orbigny 1839) var. *costata* Wiesner, **199,** 104, pl. 15, f. 173. Recent, Antarctic.

——— *tricarinata* (d'Orbigny 1826) var. *crucioralis* Wiesner, **199,** 105. Recent, Antarctic.

——— *trigonula* (Lamarck 1804) var. *angusteoralis* Wiesner, **199,** 104. Recent, Antarctic.

Miliolinella nov. gen. Wiesner, **199,** 65, 107. Recent. (Genotype: *Quinqueloculina lamellidens* Reuss, 1864.)

Nummulites atacicus Leymerie 1844 var. *aragvaensis* Renngarten, **119,** (see Jour. Paleontology, Vol. 7, p. 348), 30, pl. 3, f. 9, text f. 8–10. Eocene, Lutetian, Southern Caucasus.

Nummulites atacicus Leymerie 1844, var. *georgiensis* Renngarten, **119,** 29, pl. 3, f. 18, text f. 7. Eocene, Lutetian, Southern Caucasus.

——— ——— ——— ——— var. nov. indet. Renngarten, **119,** 31, pl. 3, f. 20. Eocene, Lutetian, Southern Caucasus.

——— *domgeri* Meffert, **181,** p. 1149 ff. Charkov Stage, Paleogene, Southern Russia. (Region of Mandrilowka).

——— *gizehensis-ehrenbergi* de la Harpe 1883 var. *armeniensis* Meffert, **182,** 16, pl. 2, f. 10–15. Eocene, Lutetian, Armenia.

——— *laevigatus* (Bruguière 1792) var. indet. (B-form) Meffert, **182,** 29, pl. 5, f. 8–10. Eocene, Lutetian, Armenia.

——— *costeri* de la Harpe 1880 var. nova indet. (A-form) Meffert, **182,** 16, pl. 1, f. 21, 22; pl. 2, f. 2–9. Eocene, Lutetian, Armenia.

——— *oswaldi* Meffert, **182,** 22, pl. 3, f. 7–12; pl. 4, f. 2–6. Eocene, Upper Lutetian, Armenia.

——— *partschi* de la Harpe 1880 var. nova indet. (B-form) Meffert, **182,** 14, pl. 1 f. 17–20; pl. 2, f. 1. Eocene, Upper Lutetian, Armenia.

Orbitella apiculata (Schlumberger 1901) var. *segmentoidea* Renngarten, **119** (see Jour. Paleontology, vol. 7, p. 348) 13, pl. 1, f. 1, 11, 12. Upper Cretaceous, Maestrichtian, Georgia, Southern Caucasus.

——— ——— (——— ———) var. *applanata* Renngarten, **119,** 13, pl. 1, f. 4, 10. Upper Cretaceous, Maestrichtian, Georgia, Southern Caucasus.

——— ——— (——— ——) var. *depressa*

* Terquem and Berthelin named "ovata" in 1875—H. J. Plummer

Renngarten, **119,** 14, pl. 1, f. 6. Upper Cretaceous, Maestrichtian, Georgia, Southern Caucasus.

——— ——— (——— ———) var. *obtusa* Renngarten, **119,** 14, pl. 1, f. 5, 9, 15–17. Upper Cretaceous, Maestrichtian, Southern Caucasus.

——— (?) *quinquecellulata* Renngarten, **119,** 15, pl. 2, f. 1. Upper Cretaceous, Maestrichtian, Georgia, Southern Caucasus.

Pellatispira armenica Meffert, **182,** 8, pl. 1, f. 5 (A-form). Eocene, Upper Lutetian, Armenia.

Pelosina elongata Wiesner, **199,** 83, pl. 6, f. 65. Recent, Antarctic.

——— *plana* Wiesner, **199,** 84, pl. 6, f. 68. Recent, Antarctic.

Planispirinella nov. gen. Wiesner, **199,** p. 69. Recent. (Genotype: *Planispirina exigua* Brady 1884.)

Planispirinellinae subfam. nov. Wiesner, **199,** new subfamily of Neusinidae Cushman 1910.

Proteonina longicollis Wiesner, **199,** 82, pl. 6, f. 55. Recent, Antarctic.

Psammophax nov. gen. Rhumbler in Wiesner, **199,** 80. Recent, Antarctic. (Genotype: *P. consociata* Rhumbler 1931).

——— *consociata* Rhumbler in Wiesner, **199,** 81, pl. 4, f. 38–40; pl. 5, f. 41–44. Recent, Antarctic.

Psammoscene nov. gen. Rhumbler in Wiesner, **199,** p. 85. Recent, Antarctic. (Genotype: *P. craterula* Rhumbler 1931.)

——— *craterula* Rhumbler in Wiesner, **199,** 85. Recent, Antarctic.

——— *opercularis* Rhumbler in Wiesner, **199,** 85. Recent, Antarctic.

Psammosphaera irregularis Wiesner, **199,** 80, pl. 4, f. 34. Recent, Antarctic.

——— *testudinaria* Rhumbler in Wiesner, **199,** 80, pl. 4, f. 35–37. Recent, Antarctic.

Pseudobolivina nov. gen. Wiesner, **199,** 99. Recent, Antarctic. (Genotype: *P. antarctica* Wiesner 1931).

——— *antarctica* Wiesner, **199,** 99, pl. 21, f. 257, 258; pl. 23, stereo-fig. c. Recent, Antarctic (for *Bolivina punctata* d'Orbigny 1839 var. *arenacea* Heron-Allen and Earland 1922).

Pseudobolivininae subfam. nov. Wiesner, **199,** new subfamily of Textulariidae d'Orbigny 1846.

Pullenia simplex Rhumbler in Wiesner, **199,** 132, pl. 22, f. 263. Recent, Antarctic.

Reophax gaussi Wiesner, **199,** 90, pl. 9, f. 106. Recent, Antarctic.

——— *margaritarius* Rhumbler in Wiesner, **199,** 90, pl. 9, f. 107. Recent, Antarctic.

——— *pauciloculatus* Rhumbler in Wiesner, **199,** 91, pl. 9, f. 108–111. Recent, Antarctic.

——— *reconditus* Wiesner, **199,** 91, pl. 9, f. 112. Recent, Antarctic.

Reophax scorpiurus Montfort 1808 var. *testacea* Wiesner, **199,** 89, pl. 8, f. 100; pl. 9, f. 101. Recent, Antarctic (for *Reophax scorpiurus* Brady 1884, Chall., p. 291, pl. 30, f. 13, 16).

Rhabdammina fusiformis Rhumbler in Wiesner, **199,** 77, pl. 2, f. 18. Recent, Antarctic.

Rhynchosaccus longus Rhumbler in Wiesner, **199,** 76, pl. 1, f. 10. Recent, Antarctic.

Saccammina tubulata Rhumbler in Wiesner, **199,** 82, pl. 23, stereo-fig. a. Recent, Antarctic.

Schellwienia chihsiaensis Lee, **97,** (see Jour. Paleontology, vol. 7, p. 347) pp. 282, 287, pl. 1, fig. 2. Upper Chihsia limestone, Permian, China. (Pro: *Fusulina* aff. *douvillei* Colani 1924, Mém. Serv. Geol. Indochine, 11, pl. 13, f. 1.)

——— *gregaria* Lee, **97,** pp. 280, 288, pl. 1, f. 3. Chuanshan limestone, Permian, China.

Simplorbites gensacicus (Leymerie 1851) var. *popaniformis* Renngarten, **119,** (see Jour. Paleontology, vol. 7, p. 348) 17, pl. 2, f. 4, 5. Upper Cretaceous, Maestrichtian, Georgia, Southern Caucasus.

Soritininae subfam. nov. Wiesner, **199,** new subfamily of Neusinidae Cushman 1910.

Spirillina decorata Brady 1884 var. *tricarinata* Wiesner, **199,** p. 127. Recent, Antarctic.

——— *dimidiata* Wiesner, **199,** 128, pl. 21, f. 250. Recent, Antarctic.

——— *tuberculata* Brady 1878 var. *plana* Wiesner, **199,** 128, pl. 21, f. 252. Recent, Antarctic.

Spiroloculininae subfam. nov. Wiesner, **199,** new subfamily of Miliolidae d'Orbigny 1839.

Staffella discoides Lee, **97** (see Jour. Paleontology, vol. 7, p. 347), p. 282, 286, pl. 1, f. 1. Upper Chihsia limestone, Permian, China.

Stortosphaera fusiformis Wiesner, **199,** 81, pl. 5, f. 46, 47. Recent, Antarctic.

Sulcophax nov. gen. Rhumbler in Wiesner, **199,** 93. Recent, Antarctic. (Genotype: *S. claviformis* Rhumbler, 1931).

——— *claviformis* Rhumbler in Wiesner, **199,** 93, pl. 13, f. 148. Recent, Antarctic.

Technitella candida Wiesner, **199,** 84, pl. 7, f. 73. Recent, Antarctic.

——— *flexibilis* Wiesner, **199,** 85, pl. 7, f. 75. Recent, Antarctic.

——— *globulus* Wiesner, **199,** 85. Recent, Antarctic.

Tholosina exigua Wiesner, **199,** 86, pl. 7, f. 84, 85. Recent, Antarctic.

——— *irregularis* Rhumbler in Wiesner, **199,** 86, pl. 7, f. 83. Recent, Antarctic.

——— *laevis* Rhumbler in Wiessner, **199,** 86, pl. 7, f. 80–82. Recent, Antarctic.

Thurammina irregularis Wiesner, **199,** 83, pl. 6, f. 62–64. Recent, Antarctic. (Note: The specific name is already preoccupied by Moreman, 1930, Jour. Paleontology, vol. 4, p. 52, pl. 6, f. 1, 5, for a Lower Paleozoic form.)

Tolypammina hedrix Rhumbler in Wiesner, **199,** 94, pl. 11, f. 130. Recent, Antarctic.

Trisegmentina nov. gen. Wiesner, **199,** 70. (Genotype: *Hauerina compressa* Sidebottom 1904 (non d'Orbigny) = *Trisegmentina sidebottomi* Cushman 1933). Recent.

Trochammina ghigii Brighenti, **149,** pp. 13–17, text f., Lagoon south of Padus delta, Italy.

Tubinellina nov. gen. Wiesner, **199,** 67, 108.

Turrispirillina turbo Wiesner, **199,** 128, pl. 21, f. 253. Recent, Antarctic.

Urnula nov. gen. Wiesner, **199,** 82. Recent, Antarctic. (Genotype: *U. quadrupla* Wiesner, 1931).

——— *quadrupla* Wiesner, **199,** 83, pl. 6, f. 56, 57. Recent, Antarctic.

Verneuilina bradyi Cushman 1911 var. *nitens* Wiesner, **199,** 99, pl. 13, f. 154. Recent, Antarctic.

——— *minuta* Wiesner, **199,** 99, pl. 13, f. 155; pl. 23, stereo-fig. d. Recent, Antarctic.

PALEONTOLOGICAL NOTES

TECHNIQUE FOR THE RECOVERY OF PALEOZOIC ARENACEOUS FORAMINIFERA

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An interesting, though slightly known, field of investigation is afforded the searcher for arenaceous foraminifera in the older Paleozoic sedimentary rocks.

Due to the fact that the reports of the few workers in this field have been restricted almost exclusively to descriptions of the fossils found in the rocks, there is scanty information available concerning any technique which has been found effective in discovering and isolating the minute tests. The procedure described below has been found very satisfactory in the examination of compact, massive limestone for its content of siliceous microfossils.

In order to separate the siliceous material from the limestone, it is advisable to follow the customary practice of dissolving away the calcareous matter in hydrochloric acid. Moreman[1] has obtained arenaceous foraminifera by dissolving large pieces of limestone in a 50 per cent solution of hydrochloric acid. Eisenack[2] recommends that a 5 per cent solution of hydrochloric acid be used. Personal experience has proved that in a number of cases the 50 per cent solution causes so violent a reaction that the delicate tests of the foraminifera are shattered and only the most solidly cemented tests remain intact. The weak 5 per cent solution, on the other hand, must be drained and replaced so frequently that the accompanying agitation, though slight, may be sufficient to crush an appreciable number of the fragile fossils. I have found a solution of 20 or 25 per cent HCl quite satisfactory in the treatment of most of the Lower and Middle Paleozoic limestones.

My method is to break the limestone into pieces about the size of marbles, place the pieces in a 500 cc. beaker or culture dish, and then pour in the acid at the rate effervescence permits until all the pieces of limestone are covered. Let it stand until all reaction has ceased. Then, using a pincers, remove the undissolved fragments from the beaker, using care to disturb as slightly as possible the indissoluble residue in the bottom of the container. Drain off the used acid either by siphoning or careful decanting. Carefully replace the undissolved limestone fragments and again pour in acid. This process should be repeated until all the soluble material has been dissolved. Caution concerning the extreme fragility of a great number of foraminiferal tests can not be overstressed and any undue agitation of the beaker or of its contents may be sufficient to shatter the delicate fossils. Accordingly, the contents of the beaker should not be stirred with a glass rod or other instrument for the purpose of attaining more thorough solution.

When, after repeated treatments with the acid, no further solution occurs, drain off all the acid and wash the insoluble residue very gently, and repeatedly, with water. A water bottle is recommended for this step and the jet of water should be directed against the sides of the beaker.

[1] Moreman, W. L., Arenaceous foraminifera from Ordovician and Silurian limestones of Oklahoma: *Jour. Paleontology*, vol. 4, pp. 43-44, 1930.

[2] Eisenack, Alfred, Neue Mikrofossilien des baltischen Silurs. 1: *Paleont. Zeitschr.*, Band 13, pp. 76-77, 1931.

If the original limestone be argillaceous, much of the insoluble residue will consist of extremely fine clay. This material must be removed because it will interfere with the subsequent microscopic examination.

An effective method of removing the clay particles, as well as other extremely minute material, is to direct the jet of water against the side of the beaker at such an angle that a whirling motion is imparted to the contents of the container. This will cause the fine material to be suspended in the liquid for a short period of time and, while in suspension, it may be transferred into another receptacle by decantation. Care in this procedure will serve to retain the coarser residue while removing the very fine and objectionable material.

Having washed the residue thoroughly and also having removed the very fine material (which may be examined separately), the examination under the microscope is the next step.

As far as known, the technique now to be explained differs radically from that usually employed by investigators of microfossils in insoluble residues.

It is customary, after washing the residue, to dry it thoroughly and then either to examine it immediately or to effect a separation in sizes by screening. Screening may be done either with the dry material or by running the residue through the screens with water and then drying.

It has been my experience to find that any screening operation, no matter how carefully done, either wet or dry, will result in the demolition of practically all the more delicate foraminifera tests. In order to preserve the tests as much as possible, the following procedure is used.

Let the insoluble residue (after the very fine material has been removed, as described above) remain immersed in about one-half inch of water. Introduce a medicine dropper, the orifice of which has been elongated and reduced to about 2 mm. internal diameter, into the liquid and, by means of the small rubber bulb, draw up a convenient quantity of the residue. Using care to exert as little force as possible, transfer the residue and water from the medicine dropper to a standard glass slide which has been placed upon the stage of the microscope. The residue, still immersed in water, should be spread in a thin sheet along the central length of the slide. Using adequate direct illumination, the residue may then be examined.

One will learn very quickly that siliceous aranaceous foraminifera can be detected under water far more readily than when dry. A thin, mounted needle should be used to probe and move the residue in order to facilitate examination.

When a foraminifera test has been discovered, using the needle, push the test very carefully to one edge of the glass slide so that the fossil becomes disengaged from the main body of water. Having thus isolated the test, observe it very closely while the small globule of water which still surrounds it evaporates. If the object under observation is a foraminifera and is hollow, its hollow interior can be proved unquestionably in that, after all the water on the outside of the test has evaporated, the water contained in the hollow interior will then evaporate and that step can be observed as it occurs. If the foraminifera be elongated and tubular, the meniscus of the evaporating water may be observed as it moves along the hollow interior. This proof of a hollow interior is very impressive and unmistakable when once seen. Such a proof is lacking when foraminifera are sought in a dry residue.

The segregated and now dried foraminifera may be removed easily to the slide upon which it is to be mounted.

In order to have sufficient illumination as well as a satisfactory source of heat to effect rapid evaporation of the water globule surrounding the segregated test, I use two properly shielded, white-frosted bulbs of 100 candlepower each, placed side by side about 3 or 4 inches directly in front of and slightly above the stage of the microscope.

A SUITABLE TRAY FOR COMPARATIVE EXAMINATION OF MINUTE OPAQUE OBJECTS UNDER THE BINOCULAR MICROSCOPE

JAMES S. CULLISON
Missouri School of Mines and Metallurgy, Rolla, Missouri

Undoubtedly all workers in the field of micropaleontology have, at one time or another, wished to study both sides of a very minute form without resorting to the tedious process of turning it over. This is especially true when a number of specimens are being compared.

For some time the author has used the working tray suggested by Dr. Joseph A. Cushman[1] which, however, does not eliminate the inconvenience suggested above. To obviate this difficulty the writer has devised a tray, somewhat similar to that of Dr. Cushman, according to the following specifications.

Cut a piece of black velvet to fit snugly in a small cardboard tray, dimensions about three-fourths of an inch by 3 inches by 4 inches. Cut a piece of plate glass mirror about one-fourth inch thick to fit tightly into the box. With a diamond point and straight-edge divide the surface of the mirror into a grid and number the sections. Approximately in the center, scratch a scale of 10 or 15 one millimeter divisions. Remove the silver from approximately one-half the surface of the mirror with nitric acid and razor blade, wash away all acid, and dry thoroughly. Place the velvet in cardboard tray with nap up. Over this lay the mirror face upward. With strips of gummed black paper tape (lantern slide tape is very good) join the edge of the surface of the mirror to the sides of the box, leaving no openings or unglued surfaces.

With this tray, and by means of slightly inclined illumination it is possible to study the details of both sides of a minute specimen with a binocular microscope, by focusing either on the object or the mirror image. With magnifications of 40 diameters or more, the object is entirely out of focus and the image can be studied in detail. In order to obtain the same result for lower powers of magnification and use the same tray, the thickness of the mirror is increased by placing plates of clear glass below the object. If this is not done a light blur from the object will be apparent when observing the image or vice versa. The portion of the mirror without the reflecting surface is used as any ordinary tray, the black velvet giving an excellent background when a low magnification is used. The grid makes it possible to segregate a great number of species, and the millimeter scale facilitates direct measurement of approximate size.

[1] Cushman, Joseph A., An introduction to the morphology and classification of the foraminifera: *Smithsonian Misc. Coll.*, vol. 77, no. 4, pp. 12, 1925.

THE FAUNA OF THE RUST QUARRY, TRENTON FALLS, NEW YORK

DAVID M. DELO
Harvard University, Cambridge, Mass.

The late Charles D. Walcott at various times published descriptions of fossils obtained from a quarry on the W. P. Rust farm a short distance east of Trenton Falls, New York. This quarry produced a vast assemblage of well-preserved fossils, among them the enrolled specimens of *Calymene* and *Ceraurus* which,

on slicing revealed to Walcott the nature of the appendages of trilobites. The Walcott and Rust collection was purchased by Alexander Aggasiz, and is now in the Museum of Comparative Zoology, Harvard University. Curiously, no list of species found in this quarry has been published, hence the following list, which it is hoped may be of service to investigators of the Trenton of New York and adjacent areas. The locality appears to be no longer available for collecting.

The writer wishes to express his gratitude to Professor P. E. Raymond, without whose assistance and encouragement the writing of this paper would have been impossible.

Unfortunately, the exact stratigraphic position of the layers supplying the fossils is still in doubt. No strata agreeing with the quarry layers in either fauna or lithology have as yet been observed in the nearby Trenton Gorge. Opinions of workers in the area agree in the conclusion that the quarry beds probably outcrop in the Gorge beneath the New York Central Railroad bridge, and these strata have been assigned to the Lower Cobourg division of the Trenton by Both Raymond[1] and Kay.[2]

The absence of *Playfairia deltoidea* and *Diplograptus amplexicaulis* from the fauna may be of some general stratigraphic significance. If the absence of these forms can be considered as established for the quarry locality, the strata exposed there must lie somewhere in the division which Raymond at one time designated as the "*Prasopora* beds,"[3] and which is bounded above and below by beds containing *Playfairia deltoidea* and *Diplograptus amplexicaulis* respectively. As this division has a thickness of 100 feet, a correlation of so general a nature is unsatisfactory, but closer allocation or the beds in question must await furthef field work in the area. It may also be significant that *Rhynchotrema*, which is found at the quarry, occurs in the gorge only in zone L of Raymond's section.[4]

The bryozoans have been identified by the writer, who believes this is the first published list of species of this group from the Trenton of the typical area. Bryozoans are enormously abundant on surfaces of slabs from the Rust quarry, but relatively few species appear to be present.

Many of the species were described by Ulrich[5] from the Decorah shales of Minnesota, This does not justify a correlation of the strata of the two localities, for little is known of the vertical distribution of bryozoans in the Trenton.

It is believed that the following list includes the majority of the forms collected from the Rust quarry, although it is recognized that some may not be included here. The types of those marked with an asterisk may be seen at the Museum of Comparative Zoology.

ECHINODERMATA

Asteroidea

Alepidaster sp.
Macroporaster matutinus (Hall)
**Urasterella medusa* Hudson
Urasterella pulchella (Billings)

Cystoidea

Ateleocystites balanoides (Meek)
Cheirocrinus anatiformis (Hall)
Cheirocrinus walcotti (Jaekel)

Crinoidea

**Calceocrinus barrandei* (Walcott)
**Dendrocrinus retractilus?* Walcott
**Ectenocrinus problematicus* Hudson
Ectenocrinus simplex (Hall)
Glyptocrinus ornatus Billings
Heterocrinus heterodactylus Hall
**Iocrinus trentonensis* Walcott
**Merocrinus corroboratus* Walcott
**Merocrinus typus* Walcott
**Raphanocrinus subnodosus* (Walcott)
**Stelidiocrinus argutus* (Walcott)

[1] Personal communications.
[2] *Ibid.*
[3] Raymond, P. E., *Bull. Mus. Comp. Zoology*, vol. 56, no. 3, p. 253.
[4] Raymond, P. E., *Bull. Am. Paleontology*, no. 17, p. 11, 1903.
[5] Ulrich, E. O., *Minnesota Geol. and Nat. Hist. Survey*, vol. 13, pt. 1, 1895.

MOLLUSCOIDEA
Bryozoa
Ceramoporella distincta Ulrich
Chasmatopora reticulata Hall
Corynotrypa cf. *delicatula* (James)
Corynotrypa cf. *inflata* (Hall)
Corynotrypa cf. *tennesseensis* Bassler
Eridotrypa aedilis minor (Ulrich)
Eridotrypa exigua Ulrich
Escharopora subrecta Ulrich
Graptodictya proava (Eichwald)
Mitoclema mundulum Ulrich
Nematopora ovalis Ulrich
Pachydictya elegans Ulrich
Pachydictya pumila Ulrich
Prasopora conoidea Ulrich
Prasopora simulatrix var. *orientalis* Ulrich
Rhindictya exigua Ulrich
Stellipora antheloidea Hall
Brachiopoda
Crania cf. *trentonensis* Hall
Schizocrania filosa Hall
Trematis terminalis (Emmons)
Dalmanella rogata (Sardeson)
Platystrophia amoena McEwan
Rafinesquina alternata (Emmona)
Rhnychotrema increbescens (Hall)
Skenidioides halli Safford
Sowerbyella sericea (Sowerby)
Zygospera recurvirostris (Hall)
MOLLUSCA
Conularia papillata Hall
Conularia trentonensis Hall
Sinuites cancellatus Hall
CRUSTACEA
Trilobita
Acidaspis trentonensis Walcott
**Amphilichas inaequalis* Raymond
Bumastus holei Foerste
**Bumastus porrectus* Raymond
Calymene senaria Conrad
Ceraurus dentatus Raymond and Barton
Ceraurus pleurexanthemus Green
Encrinurus vigilans Hall
Illaenus americanus Billings
Isotelus gigas Dekay
Isotelus walcotti Ulrich
Trilobita cont'd.
Pterygometopus achates (Billings)
Pterygometopus callicephalus (Hall)
Pterygometopus eboraceus Clarke
**Remopleurides striatulus* Walcott
**Sphaerocorphe robusta* Walcott
Ostracoda
Tetradella subquadrans Ulrich
Incertae sedis
**Conchopeltis alternata* Walcott
Lepidocoleus jamesi Hall and Whitfield

Almost all of the fossils are weathered out in relief on the surface of slabs. Most abundant in point of numbers of individuals are the bryozoans, which cover the surface of some layers with a network of well preserved zoaria. The more common species include *Prasopora simulatrix* var. *orientalis*, *Prasopora conoidea*, *Mitoclema mundulum*, *Rhinidictya exigua*, *Eridotrypa exigua* and *Pachydictya elegans*.

The surface of those layers supporting few bryozoans contain abundant crinoid calyxes and columns. The most common are *Calceocrinus*, *Ectenocrinus*, *Heterocrinus* and *Iocrinus*.

Brachipods are not abundant, although *Dalmanella rogata*, *Sowerbyella sericea*, and *Zygospira recurvirostris* are common on some slabs.

Trilobite remains are abundant, but four of the species listed make up 95 per cent of the individuals present. These are in order of their abundance, *Calymene senaria*, *Ceraurus pleurexanthemus*, *Isotelus gigas*, and *Acidaspis trentonensis*. Other species are rare.

Ostracoda are rare and only a few individuals of *Tetradella subquadrans* have been observed.

SOCIETY RECORDS AND ACTIVITIES

SUMMARIZED MINUTES OF THE EIGHTH ANNUAL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

President, F. B. Plummer, in the chair
Vice-President, H. G. Schenck (absent)
Secretary-Treasurer, Gayle Scott
Editor, Raymond C. Moore

The eighth annual meeting of the Society of Economic Paleontologists and Mineralogists was held in the Baker Hotel at Dallas, Texas, Friday, March 23, 1934, in conjunction with the regular annual meeting of the American Association of Petroleum Geologists.

The morning session of the meeting was called at 9:00 A.M. for the presentation of papers. The papers on the Tertiary symposium were presented.

Mr. W. H. Twenhofel of the University of Wisconsin was the principal speaker at the luncheon.

The afternoon session was called at 2:00 o'clock and the second part of the program, including all general papers, was presented. As the business meeting was scheduled for 4:00 P.M. the presentation of the last four papers was postponed until later. The following items of business were considered by the Society members in the order listed:

1. President Plummer suggested that since the minutes of the previous meeting had been published in the *Journal of Paleontology* their reading could be dispensed with.

2. The President made his annual report, and passed the following three suggestions on to the incoming officers:

(a) To foster an up-to-date bibliography on all foraminiferal literature published.
(b) To distribute correlation charts including the commonest index fossils used by economic workers. This will be a way of using the same language, nomenclature, names, etc. The size might range from an 18 inch to one-yard square.
(c) To continue the negotiations with the Paleontological Society toward joint publication.

3. Mr. Scott did not read all of his report as the time was short and the report was to be published in the June issue of the *Journal of Paleontology*.

4. The Editor stressed the fact that although the quantity of material published in the *Journal of Paleontology* had been increased and highest quality of publication maintained, the amount expended for the *Journal of Paleontology* is now far lower than ever before. Many important savings in cost of printing have been made through the contract now in force with the Banta Publishing Company, through the adoption of a two-column set-up in page style and through a new contract for plates. There is a growing interest in the *Journal of Paleontology* which has been partly due to the introduction of full-tone plates. Announcement was made of a grant of $750.00 from the National Academy of Sciences to help in this year's (1934) expenses in connection with publication of the *Journal of Paleontology*.

Mr. Moore was relieved of much work in connection with the *Journal of Sedimentary Petrology* by Mr. W. H. Twenhofel who served as editor in 1933.

5. Mr. Twenhofel reported that the *Journal of Sedimentary Petrology* had sufficient papers on mineralogy at present but would need more in the future. He also stated that one of the aids in keeping the *Journal* out of debt this year was a gift of $150.00 from the Committee on Sedimentation of the National Research Council.

6. The report of the Committee on Joint Publication with the Paleontological Society was given by Marcus A. Hanna. The only solution, Mr. Hanna pointed out, is to ask the Paleontological Society to accept our membership. In the form of a motion, he stated that:

"the Council be authorized to submit the membership list of the S.E.P.M. to the P.S. with recommendation that members of the S.E.P.M. shall be designated also as members of the P.S. (a) provided that the granting of such P.S. membership shall involve no payment of additional dues to the P.S., (b) provided also that the name and all existing features in the organization of the S.E.P.M. shall remain unchanged or subject to the control of this Society, and (c) provided further that the membership of the S.E.P.M. shall be adequately represented on the Council of the P.S."

N. L. Thomas, W. H. Twenhofel, Karl Young and Raymond C. Moore and others discussed the motion. Mr. Hanna's motion was carried with one dissenting vote.

Mr. Plummer stated that ballots and letters explaining the plan in detail will be sent the membership.

Hanna moved that the ballots need not be signed. Seconded and carried.

(*Note.*—Subsequent conferences with the Executive Committee of the American Association of Petroleum Geologists and others has made it inadvisable to proceed with this action.)

8. The Secretary announced the results of the mail ballot for the nomination of officers for the ensuing year.

The nominations were as follows:

For president: F. B. Plummer and N. L. Thomas.

Mr. Plummer's name was withdrawn as the president may only be elected for the one year. Stevenson moved that there be no other nominations. Twenhofel seconded and the vote was carried. Moore moved that the secretary cast a unanimous vote for N. L. Thomas as the ensuing president. Seconded and carried.

For vice-president: H. G. Schenck, J. B. Knight, Merle C. Israelsky, Alva C. Ellisor.

In a written ballot, Mr. Israelsky and Miss Ellisor received the highest number of votes. After another written ballot Mr. Israelsky was voted vice-president for 1934.

For secretary-treasurer: Gayle Scott.

No nominations were made from the floor. Mr. C. E. Decker moved that the secretary cast a unanimous vote for the secretary-treasurer, Gayle Scott. Seconded.

For editor: Raymond C. Moore, G. Dallas Hanna.

In a written ballot Mr. R. C. Moore was elected editor.

It was moved and seconded that a vote of thanks be given the local committee for their efforts. Seconded.

The meeting was adjourned until 9:00 A.M. Saturday morning, at which time the remaining papers were presented.

The following papers were presented at the technical sessions of the Society:

I. TEXAS AND LOUISIANA TERTIARY WITH SPECIAL EMPHASIS ON ZONATION OF DIFFERENT GROUPS

1. "Ostracoda of the Midway of Texas," *C. I. Alexander.*
2. "Tentative Foraminiferal Zonation of the Claiborne," *M. C. Israelsky.*
3. "Sparta-Crockett Transition on Brazos River, Texas," *H. B. Stenzel.*
4. "Sabine-Eocene Ostracodes," *H. V. Howe and J. B. Garrett, Jr.*
5. "Use of Small Macrofossils in Correlation," *H. B. Stenzel.*
6. "Larger Foraminifera from the Moody's Branch Marl, Jackson Eocene of Texas, Louisiana, and Mississippi," *M. A. Hanna and D. W. Gravell.*
7. "Zonation of Oligocene of Texas, Louisiana, and Mississippi," *M. A. Hanna and D. W. Gravell.*
8. "Jackson-Oligocene Ostracoda from Gulf Coast," *R. W. Harris and V. L. Frost.*
9. "*Bitubulogenerina*, A New Eocene Genus of Foraminifera," *H. V. Howe.*
10. "*Bairdia subdeltoidea* (Munster) in American Tertiary," *H. V. Howe.*
11. "Formation of Upper Miocene of San Joaquin Valley, California," *Paul P. Goudkoff.*
12. "Progress Account of Committee on Revision of Miocene Nomenclature in California," *A. J. Tieje.*

13. "Diagnostic Foraminifera of Kincaid and Wills Point Formations in Texas," *Helen Jeanne Plummer.*

II. General Papers

1. "Some New Species of Ostracodes and Conodonts from Francis Formation of Oklahoma," *R. W. Harris and Dan Jones.*
2. "Progress in Investigation of Conodonts at the University of Missouri," *E. B. Branson and M. G. Mehl.*
3. "Value of Study of Type Specimens of Foraminifera," *J. A. Cushman.*
4. "Graptolites of Sylvan Shale of Oklahoma," *Charles E. Decker.*
5. "Mississippian-Pennsylvanian Boundary in Mid-Continent Region," *R. C. Moore.*
6. "Jurassic Ostracoda," *J. F. Roberts.*
7. "Notes on Gober Chalk," *E. M. Rice.*
8. "Correlation of Pecan Gap Chalk Group in Texas," *L. F. McCollum, A. C. Ellisor and John Teagle.*
9. "Coprolite Horizon in Pennsylvanian of Chafee and Park Counties, Colorado," *J. Harlan Johnson.*
10. "Algae of Genus *Ottonosia* from Pennsylvanian of Central Colorado," *J. Harlan Johnson.*
11. "Study of Micropaleontology and Stratigraphy of Dower Pennsylvanian of Central Missouri," *W. F. Bailey.*
12. "A Cretaceous Ammonite with an Anomalous Suture Pattern," *Gayle Scott.*
13. "Heavy Minerals of Some Front Range Granites," *Margaret Fuller Boos.*
14. "Comparison of Sediments in Lower Part of Clarinda (Iowa) Deep Test and 'Red Clastics' of Minnesota," *A. C. Tester.*

REPORT OF THE SECRETARY-TREASURER

March 15, 1934

The membership of the Society of Economic Paleontologists and Mineralogists on March 15, 1934, numbered 199 active members and 78 associate members. Dues were collected on January 1st, 1934, for 1934. During the year, March 15, 1933, to March 15, 1934, the Society elected 5 new active members and 10 new associate members. Applications now pending number 19.

The secretary has directed his energies toward maintaining and increasing the revenues of the Society through the sale of back numbers of the *Journal of Paleontology*, obtaining new subscriptions, new members, and advertising for the *Journal of Paleontology*. The total paid subscription list of Volume 7 of the *Journal of Paleontology* amounts to 492. The total paid circulation of the *Journal of Sedimentary Petrology*, Volume 3, amounts to 269. At intervals circular letters and advertisements illustrating and describing the publications of the Society have been sent out to libraries and laboratories, and to geologists and paleontologists in this country and abroad. A number of letters have also been written to prospective advertisers soliciting business. The total advertising amounts to approximately four pages yielding $130.60 revenue. One page, advertising the publications of the American Association of Petroleum Geologists, is in exchange for an advertisement of publications of the Society in the *Bulletin*, and the one-sixth page advertisement of Max Weg is in exchange for a similar amount of space in *Der Geologie*.

On the Pacific Coast and in the larger cities in Oklahoma, Louisiana, and Texas, local sections have continued active and interesting monthly meetings have been held. It is hoped that these activities will continue and that additional local sections will be organized.

Both volumes of the 1933 issues of the Journals were printed by the George Banta Publishing Company at Menasha, Wisconsin. The full tone plates in the *Journal of Paleontology* were printed by the Meriden Gravure Company at Meriden, Conn.

Altogether, Volume 7 of the *Journal of Paleontology* contains 447 pages, 50 plates, and was printed in lots of 1,000 at a total cost of $2,649.41. Volume 3 of the *Journal of Sedimentary Petrology* contains 140 pages, and was printed in lots of 600 at a cost of $673.16.

The present financial status of the Society is satisfactory as shown by the following statement:

CASH AUDIT

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS
March 15, 1933, to March 15, 1934

March 20th, 1934.

This is to certify that I have audited the records of the secretary-treasurer of the Society of Economic Paleontologists and Mineralogists for the period March 15, 1933, to March 15, 1934, and the following represents, in my opinion, a correct statement of receipts and disbursements for that period.

JOHN W. BALLARD
Certified Public Accountant

STATEMENT OF SAVINGS ACCOUNT OF THE

Society of Economic Paleontologists and Mineralogists for the year March 15, 1933, to March 15, 1934

Balance March 15, 1933	$2,567.40
Interest July 1, 1933	26.75
Interest January 1, 1934	26.17
Deposit February 21, 1934	1,000.00
	3,620.32
Withdrawal July 7, 1933	500.00
Balance March 15, 1934	$3,120.32

The above amount in savings account No. 27574 of the Fort Worth National Bank of Fort Worth, Texas.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS

Society of Economic Paleontologists and Mineralogists
For the year March 15, 1933 to March 15, 1934

RECEIPTS

Balance March 15, 1933	$3,062.77
Membership dues	1,054.50
Donations toward publication A.A.P.G.	348.00
Subscriptions	3,008.71
Advertising	130.60
Plates	32.90
Interest on savings Account	52.92
N. R. C. Subsidy	150.00
Heleotyping	50.00
Sale of articles	63.25
Redeposited checks, Miscellaneous, etc	128.09
	$8,081.74

DISBURSEMENTS

Secretarial and clerical work	$570.00	
Telephone and Telegraph	7.42	
Postage	193.00	
Tax on Checks and Collection items	1.40	
Office Expense	84.00	
Reprints	40.12	
Journal front covers	34.36	
Auditing	25.00	
Refunds	7.20	
Printing:		
Journal of Paleontology:		
March	672.28	
June	607.24	
September	760.47	
December	609.42	
Journal of Sedimentary Petrology:		
April	224.95	
August	232.77	
December	215.44	
Redeposited Checks	128.80	4,413.87
Balance March 15, 1934		$3,667.87

Reconciliation of Balance:

Balance, Savings Account March 15, 1934	$3,120.32
Balance, Checking Account March 15, 1934	1,382.41
	4,502.73
Checks Outstanding	834.86
Balance March 15, 1934	$3,667.87

STATEMENT OF ASSETS

Society of Economic Paleontologists and Mineralogists
March 15, 1934

ASSETS

Bank Balance:			
Savings Account		$3,120.32	
Checking Account		547.55	$ 3,667.87
Stock of Journals:			
Journal of Paleontology:			
Volume 2	(49 copies)	294.00	
Volume 3	(76 copies)	456.00	
Volume 4	(303 copies)	1,818.00	
Volume 5	(354 copies)	2,124.00	
Volume 6	(410 copies)	2,460.00	
Volume 7	(460 copies)	2,760.00	9,912.00
Journal of Sedimentary Petrology:			
Volume 1	(245 copies)	735.00	
Volume 2	(300 copies)	900.00	
Volume 3	(412 copies)	1,236.00	2,871.00

Bills Collectible:		
Membership Dues	348.00	
Sales of Journals	888.00	
(47) Journal of Sedimentary Petrology Subscriptions	141.00	
(51) Journal of Sedimentary Petrology Dues	102.00	
Advertising	195.63	
Due for back issues of Journals	206.70	1,881.33
Total		$18,332.20

COMMENTS

Checking account carried at Fort Worth National Bank of Fort Worth, Texas.
All checks supported by vouchers.
Records are kept in a very satisfactory manner.
The audit did not cover a verification of assets shown in the Statement of Assets. It covered only a check of the cash receipts and disbursements.